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# Evaluation of the Modified MATTS

by

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Technical Documentary Report No. APGC-TDR-62-14

MARCH 1962

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DEPUTY FOR AEROSPACE

AIR PROVING GROUND CENTER

Air Force Systems Command

United States Air Force

Eglin Air Force Base, Florida



APGC Project No. 7840W3

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## FOREWORD

This test, Project 7840W3, was authorized by DD Form 613, RDT and E Project Card, for Project 7840, dated 4 February 1961.

The majority of the resources required to accomplish the testing were supplied by the 4750th Test Squadron, 73rd Air Division, Air Defense Command, Tyndall AFB, Florida. Acknowledgement for intensive effort toward test accomplishment is given to Major Norman Pawloski (ADC Project Officer) and the MATTS operating crew of the Cubic Corporation. The test was conducted during the period 24 April to 3 December 1961.

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## ABSTRACT

The purpose of this test was to evaluate the capability of the modified MATTS to achieve, at minimum, premodification accuracies. Three MATTS configured aircraft were utilized to simulate the vehicles involved in the MATTS measurement of a typical intercept. Data were collected on pertinent flight paths within the MATTS operational envelope.

Tracking accuracy is satisfactory or acceptable throughout the tested profile except at the extreme western end of the SAGE drone track, where the errors are too large for MATTS application. Spatial position accuracies are comparable to those obtained from the original MATTS. Scoring accuracy meets the required accuracies for miss and escape distance calculations within the testing area flown to assess these accuracies, with the following exceptions: the extreme western end of the SAGE drone track, the south leg of the SAGE drone track, and the 60 and 80 NM legs parallel to the Y base line out over the firing range.

It is recommended that future experiments over the desired operational area be conducted only after a complete analysis of all the data collected on the MATTS, and after as many known discrepancies as possible have been corrected. Also, it is recommended that any further evaluation utilize live firings as a primary means of obtaining data.

## PUBLICATION REVIEW

*This technical documentary report has been reviewed and is approved.*



ROBERT H. WARREN

Major General, USAF

Commander

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## SECTION 1 - INTRODUCTION

Development, under the direction of the Air Force Systems Command (AFSC), was begun in the spring of 1958 on a system that would satisfy the Air Defense Command (ADC) requirement for a trajectory recording scorer for the Genie (MB-1T) rocket. During the period between June and September 1958 the Multiple Airborne Target Trajectory System (MATTS) (AN/GSQ-29) was constructed and installed at Tyndall AFB to satisfy the ADC requirement. MATTS was designed to track an interceptor, target, and rocket simultaneously and plot the trajectory of any two of the three airborne vehicles (Fig. 1). The final results obtained from the system are the miss (burst) distance of the rocket with respect to the target and the escape distance of the interceptor with respect to the rocket.

The MATTS is utilized by ADC at Tyndall Air Force Base for aircrew and weapon system tactical evaluation.

The system was originally tested under APGC Project 7840W1 during 1959-1960; the results of that test are presented in Reference 1. Originally, MATTS utilized electro-mechanical servos for tracking airborne vehicles. During March 1961, the electro-mechanical servos were replaced by electronic phase meters. This test, APGC Project 7840W3, was conducted to assess the changes, if any, in the system operation due to the modification. Acquisition time, frequency cross talk, tracking accuracy, space position accuracy, and scoring accuracy were investigated. Specifications required that the improved system performance and accuracy be at least equal to the performance of the original system. Whenever possible, the results obtained during this test were compared with the results obtained during the test of the original system.

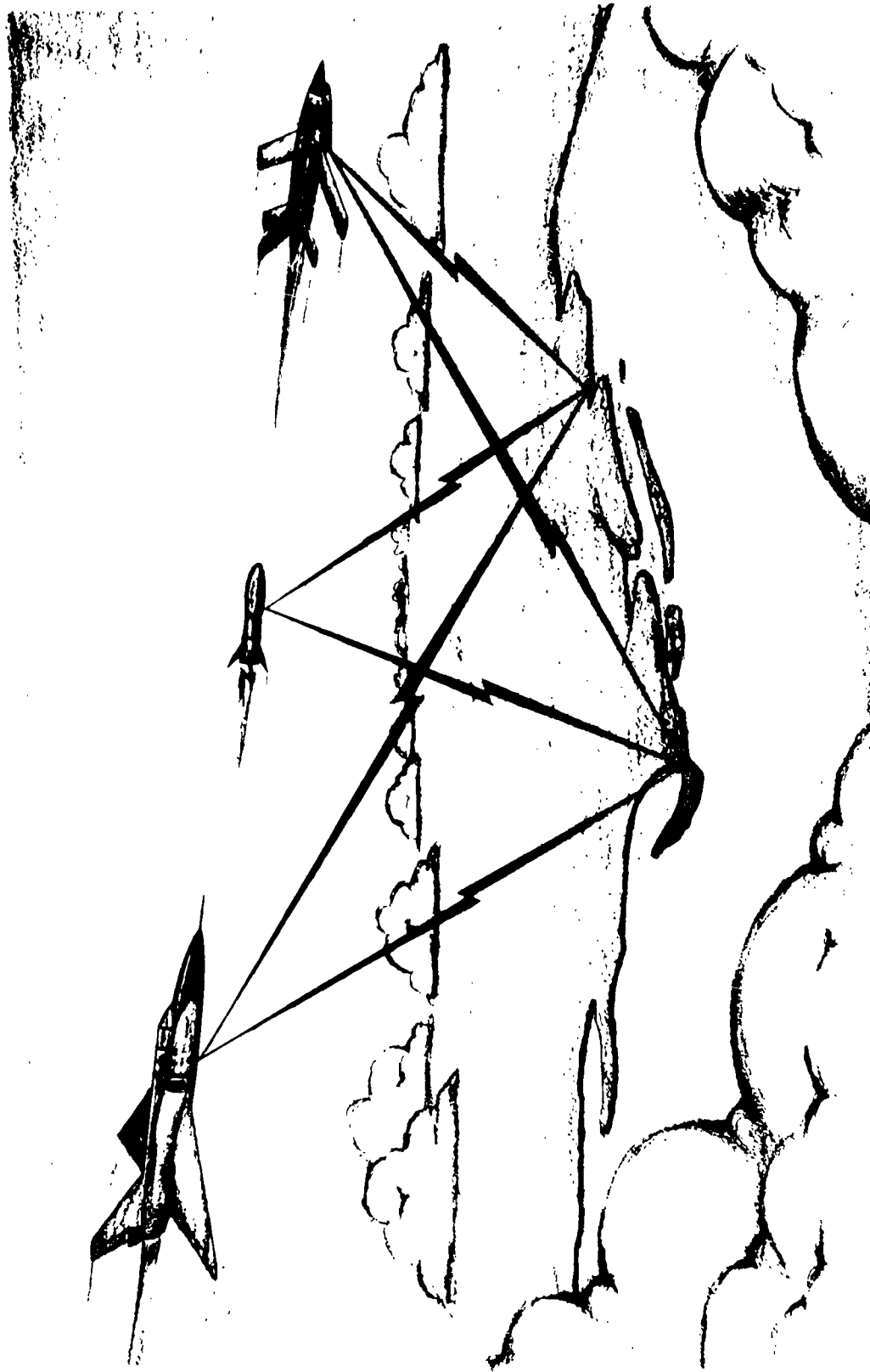


Fig. 1: Artists Conception of the MATTS Operation

## SECTION 2 - TEST ITEM DESCRIPTION

The Multiple Airborne Target Trajectory System consists of two on-range angle measuring equipment (AME) sites and a computer control site approximately 50 miles away from the firing range. Data from the AME sites at Cape San Blas and Carrabelle, Florida, are transmitted to the control site located at Tyndall AFB via a microwave data link. The system records direction cosine data, frequency count, launch-burst indications, quality, parity, a timing pulses and computes the distances (in feet) between the rocket burst and the target and interceptor. All measurements for firing events are based on the distances from the sites relative to the X and Y base lines shown in Fig. 2. As can be seen from the figure, the X base line for each site extends out over the firing range above the Gulf of Mexico. This direction is plus for the X base line. The Y base line for each site theoretically passes over the origin of the other site intersecting the Z axis of that site, with the plus direction being eastward.

The AME sites (Fig. 3), through their antenna fields, receive continuous UHF signals from each of three airborne vehicles. Each AME site antenna field consists of six antenna pairs, two each for coarse, intermediate, and fine channels. The distances between the antennas of each pair for each channel are 50, 6.25, and 5.86  $\lambda$ , respectively, (where  $\lambda$  is the wavelength of a 225 Mc frequency source).

The data received by the antennas are converted from analog to digital form by the phase meters and transmitted as direction cosine data to the control site at Tyndall (Fig. 4) via a microwave data link at a selected operational rate of 20 samples per second. The data from both tracking sites are received by a buffer unit which synchronizes and presents them to the computer. The data are sent to the computer and simultaneously recorded on magnetic tape. From the computer the reduced data are sent to plotting boards where approximately one data point per  $2\frac{1}{2}$ -sec interval is utilized in presenting vehicle trajectories.

During a firing mission, while tracking all three vehicles, the system plots the trajectories of the interceptor and the target until the rocket is launched. At rocket launch the system begins to plot the target and the rocket. These tracks continue until the rocket explodes. The data are used by the computer to calculate miss and escape distances which are printed out by an electric typewriter. The type-out also shows the space position (X, Y, Z) of the rocket burst with respect to the target (miss distance) and with respect to the interceptor (escape distance). Upon completion of the calculation, the system returns to plotting trajectories

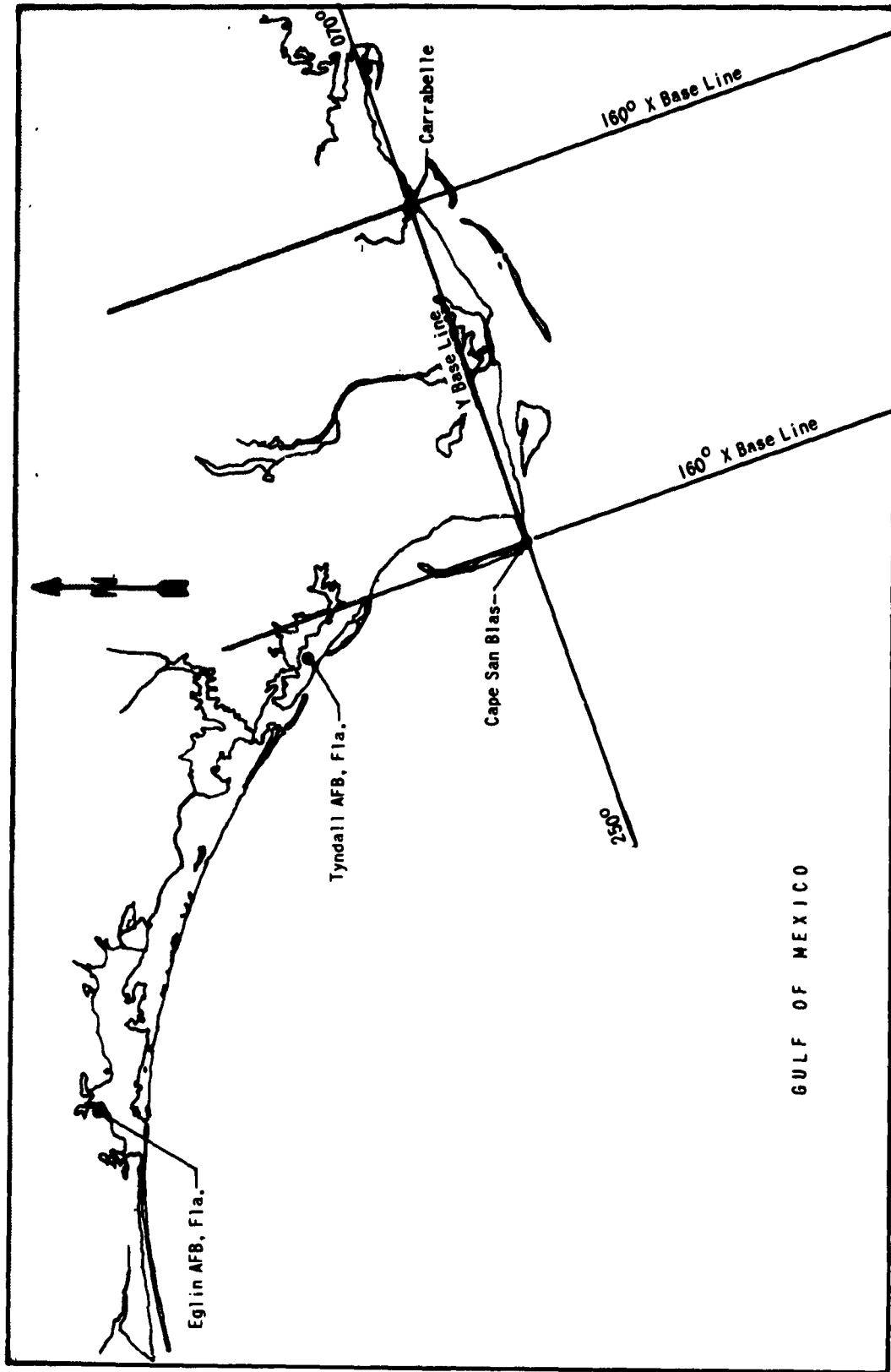


Fig. 2: Location of the MATTS AME Sites Along the Gulf Coast

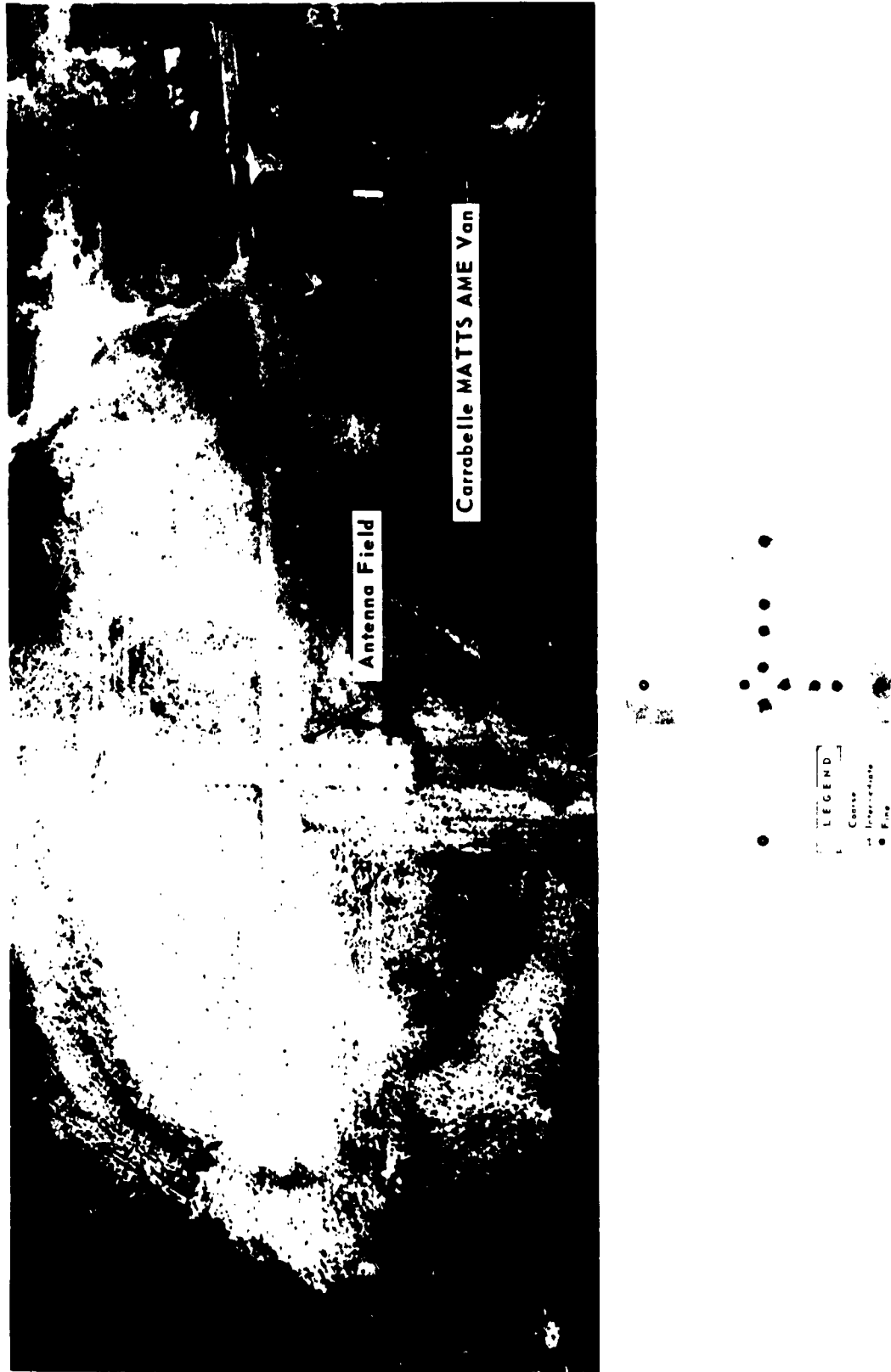


Fig. 3: Antenna Field Configuration at One of Two Similar AME Sites

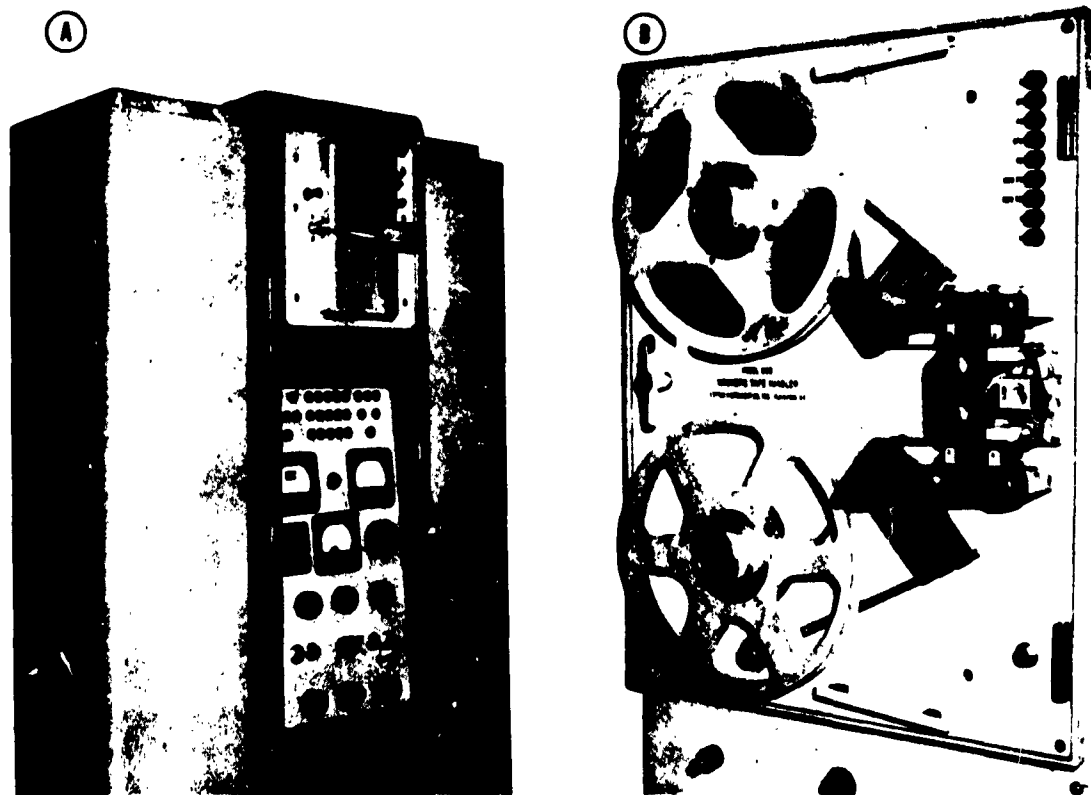
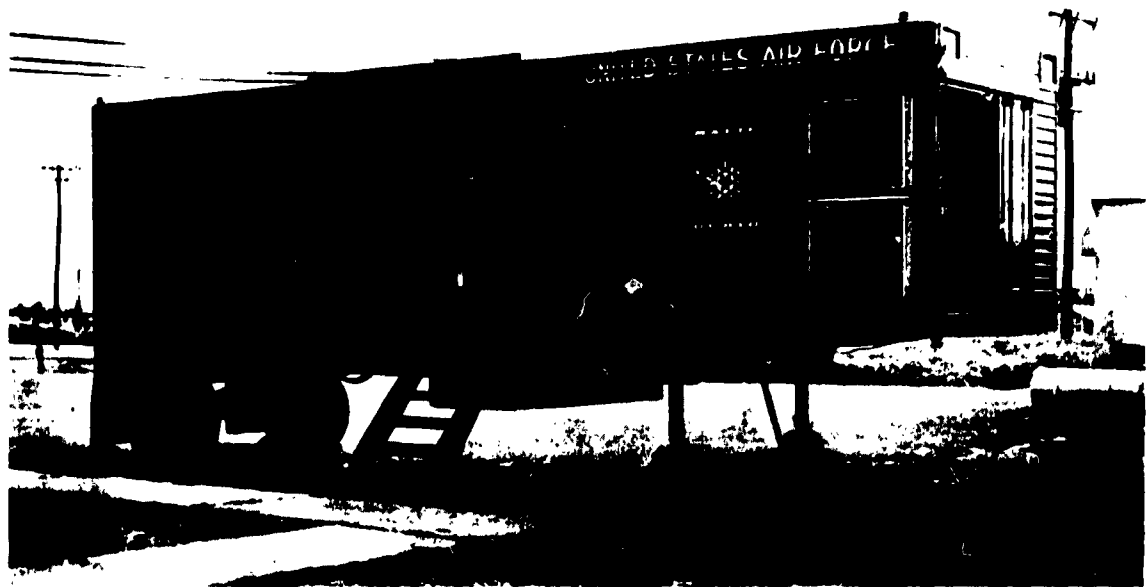


Fig. 4: Computer Control Van: (A) Computer and (B) Tape Handler Located Inside the Van

of the interceptor and the target. In this manner the accuracy of a firing can be determined in as little as 12-31 sec after the actual event.

A more detailed description of the system and its operation may be obtained from References 1 and 2. This report describes only the phase meters in detail.

There is one phase meter at each AME site. The phase meter utilizes the six antenna pairs, each of which receives all three frequencies (221 Mc for the interceptor, 224 Mc for the target, and 225 Mc for the rocket). For each of the three frequencies received by each antenna pair there is one data servo, making a total of 18 servos. A bank of data servo cabinets is shown in Fig. 5. Fig. 6 presents a block diagram of the reception and processing of the airborne signals. Only one antenna pair and one frequency are used for the illustration. The signal is received by the antenna pair, amplified by the RF preamplifiers, and sent to the receiver. At the receiver the signal is mixed with a constant frequency RF signal from the dual local oscillator to produce an IF data signal. The dual local oscillator also produces a 1kc reference signal which is sent to the reference servo in the phase meter. The phase difference between the IF data signal and the 1kc reference signal is proportional to the phase difference between the signals received at the individual antennas of a pair. The IF data signal is sent from the receiver to the data servo where the analog signal is digitized. The digitized signal then goes to the processor (Fig. 7) where it is compared with the digitized 1kc reference signal. The processor produces the difference between these two digitized signals as a binary representation of direction cosine.

The direction cosine word consists of 19 bits (18 data bits and 1 sign bit). The first four bits of the word, which are the most significant, are obtained from the coarse antennas. The next three bits are obtained from the intermediate antennas, and the last 12 bits of the word originate from the fine antennas. The direction cosine word is then sent from the phase meter to the control site via a microwave data link.

A simplified block diagram of a data servo is shown in Fig. 8. A unit diagram of the fine data servo may be seen in Fig. 9. It should be noted that the coarse and intermediate data servos differ from the fine data servo in the following ways only: they do not have feedback from the digital counter, and the counters in the coarse and intermediate servos are 8-bit counters rather than the 13-bit counter found in the fine data servo. The function of this counter is to convert received analog data to digital data. In respects other than the cited differences, the data servos are alike.

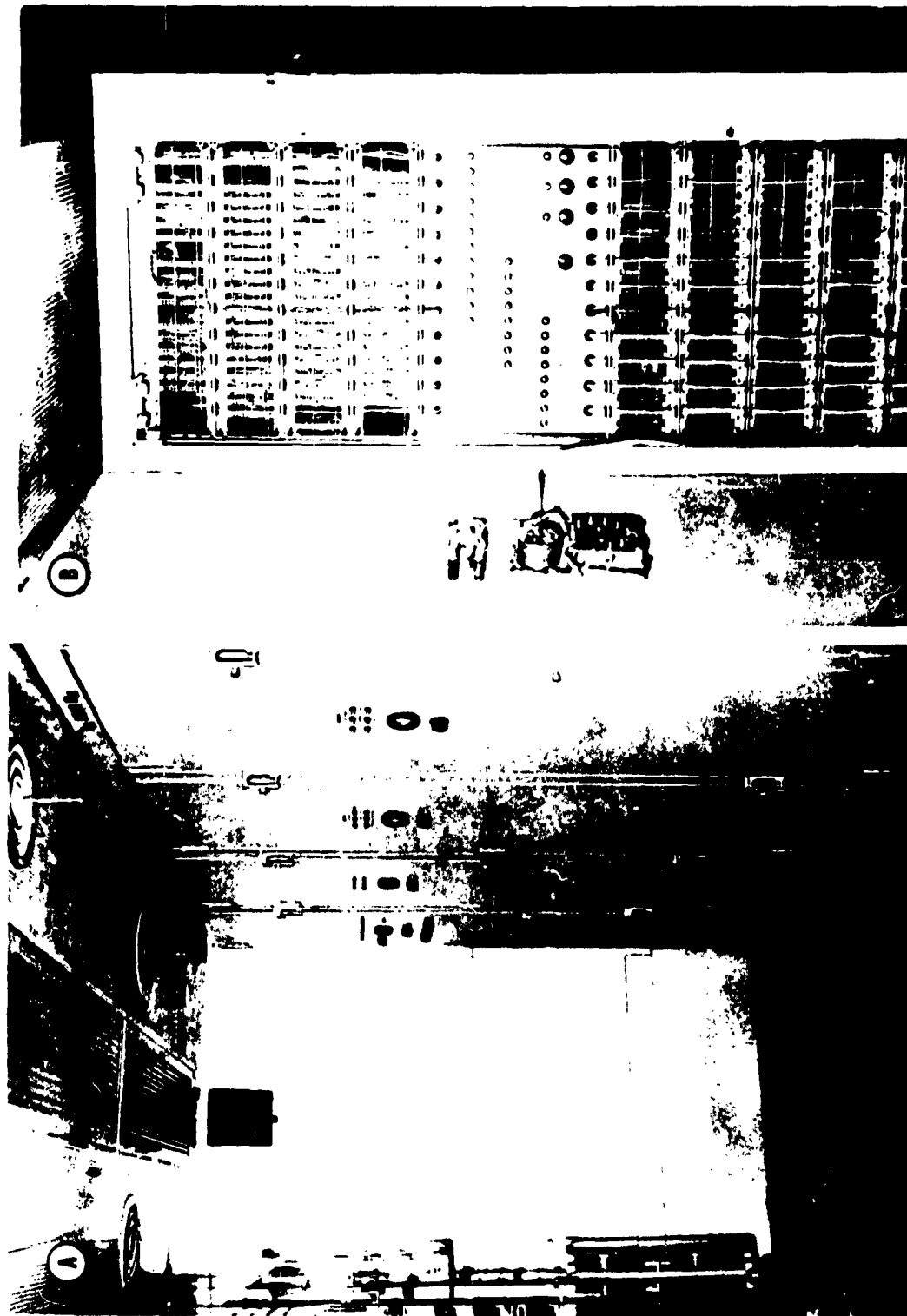


Fig. 5: Data Serv Cabinets at One of Two Similar AME Sites, (A) Exterior View and (B) Interior View

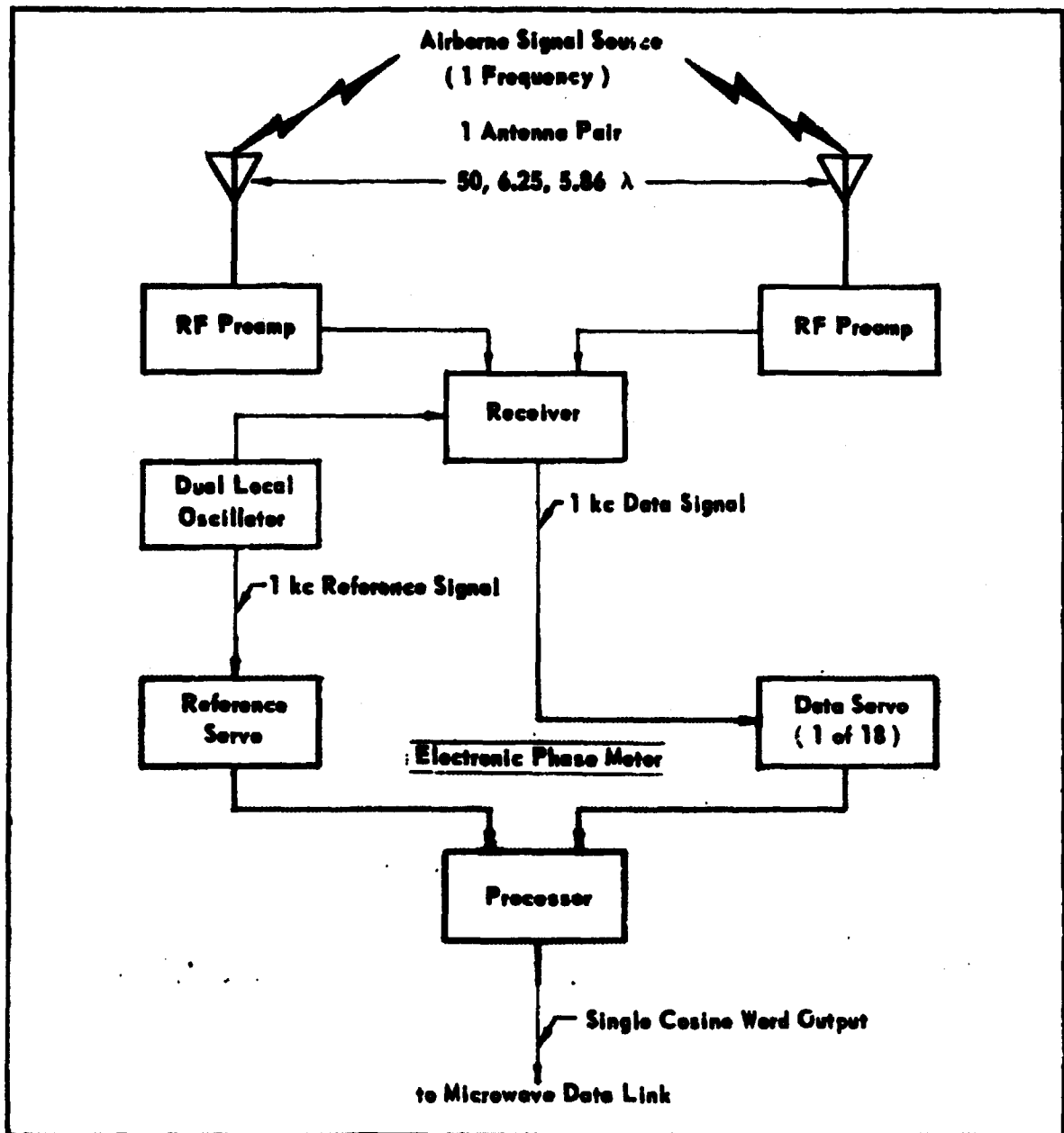


Fig. 6: Block Diagram Showing Reception and Processing of Airborne Signals at an AME Site

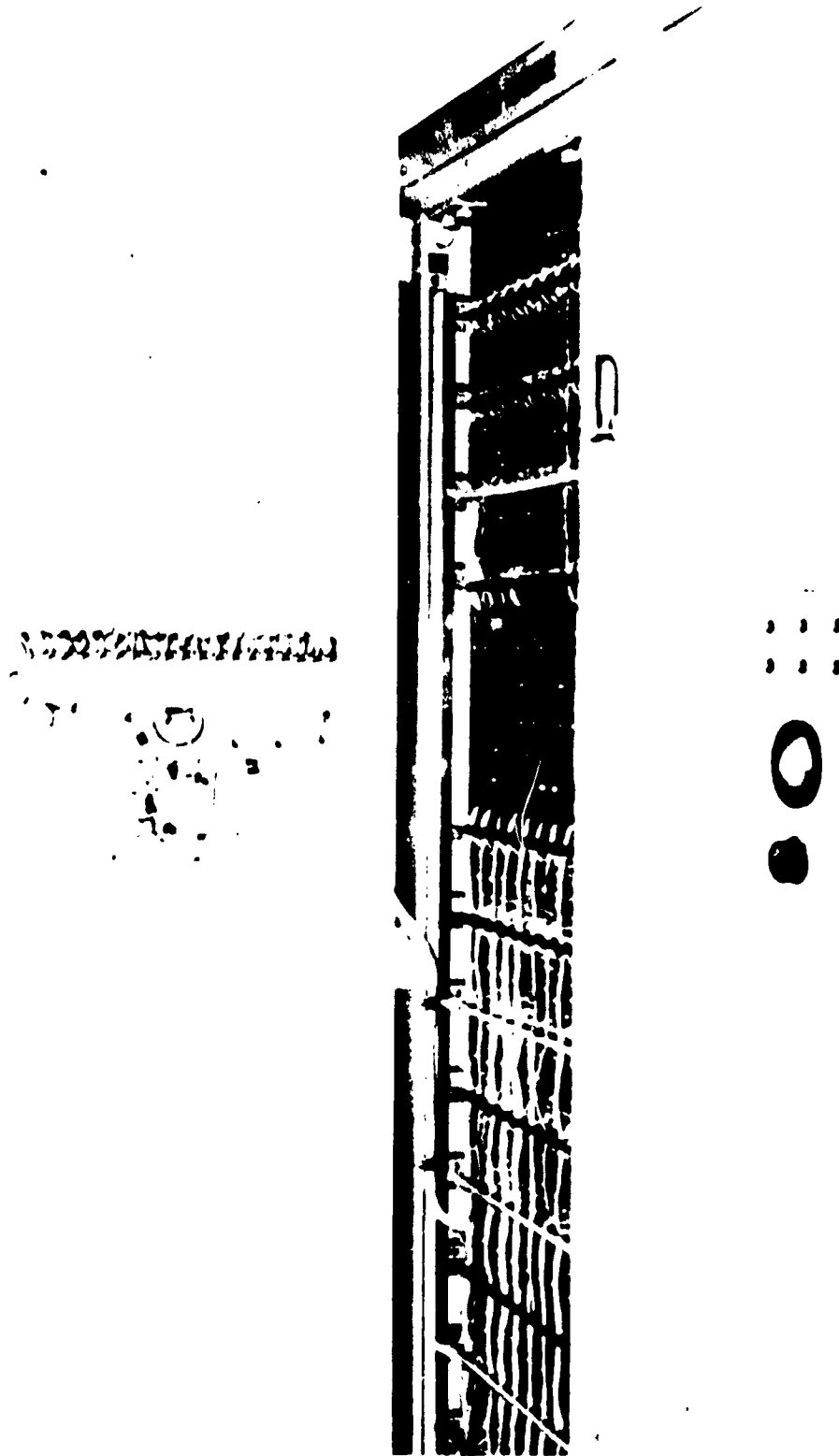


Fig. 7: Digital Data Processor in the AME Site Van

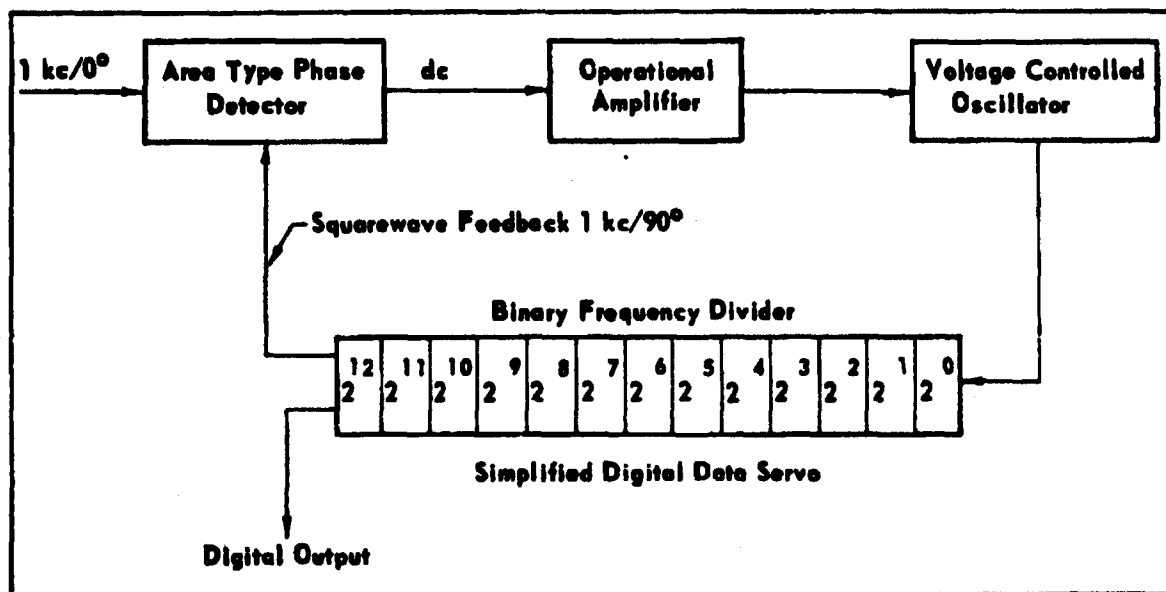


Fig. 8: Simplified Block Diagram of a Data Servo

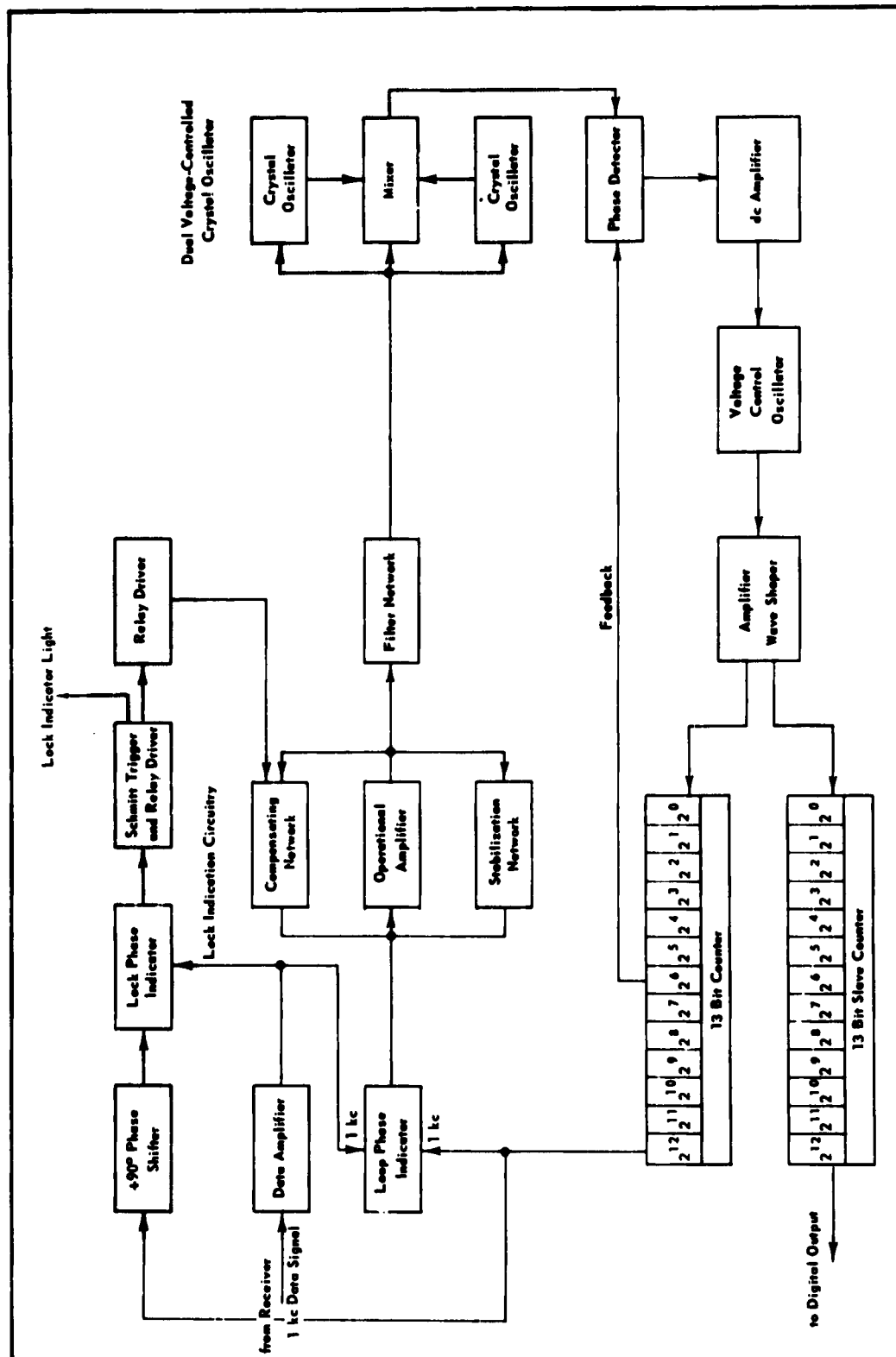


Fig. 9: Block Diagram of a Fine Data Servo

## SECTION 3 - PROCEDURES, RESULTS, AND DISCUSSION

## SYSTEM ACQUISITION TIME

PROCEDURE. The MATTS utilizes electronic equipment as stated earlier; therefore, there is an inherent lag or delay in the response of the system. This delay is called the system acquisition time. The profile of the missions flown to assess this delay time is shown in Fig. 10. The missions were flown over an area encompassing the SAGE drone pattern and portions of water range W-470.

Two frequencies, which were alternated every 6 sec, were transmitted from one T-33 aircraft utilizing one antenna to simulate the tracking transition from interceptor to missile. When the frequencies were switched, the system had to reacquire the new frequency to track it. The time required for the system to lock-on and track the new frequency was measured by timing the rise of the voltage in the fine data servo from the instant the airborne source was switched from standby to transmit until lock-on voltage (20 mv) was attained. A constant frequency (establishing a steady reference track simulating the MATTS target) was transmitted from a second T-33 aircraft one mile aft and one mile starboard of the first aircraft.

RESULTS. The measured acquisition times are shown in Table 1. Because the acquisition times of the old electro-mechanical servos were not measured, no comparison can be made of the acquisition times of the original MATTS and those of the modified equipment. Acquisition times may also be seen in Table 2 (samples 35156 to 35171) and Table 3 (samples 44170 to 44181). Total times involved were 0.6 sec and 0.55 sec respectively.

## FREQUENCY CROSS-TALK

PROCEDURES. In any electronic equipment with a multi-frequency capability, such as the MATTS, there is a possibility that the separate frequencies will interfere with one another. If this situation should occur, the data for each frequency involved would be distorted and invalid. This possibility was checked, utilizing the same flight profile as that flown to assess the system acquisition time (see Fig. 10). The mission was flown at altitudes of 10,000, 20,000, 30,000 ft in an area over the water range most advantageous to the MATTS equipment, so as to eliminate as many unknowns as possible.

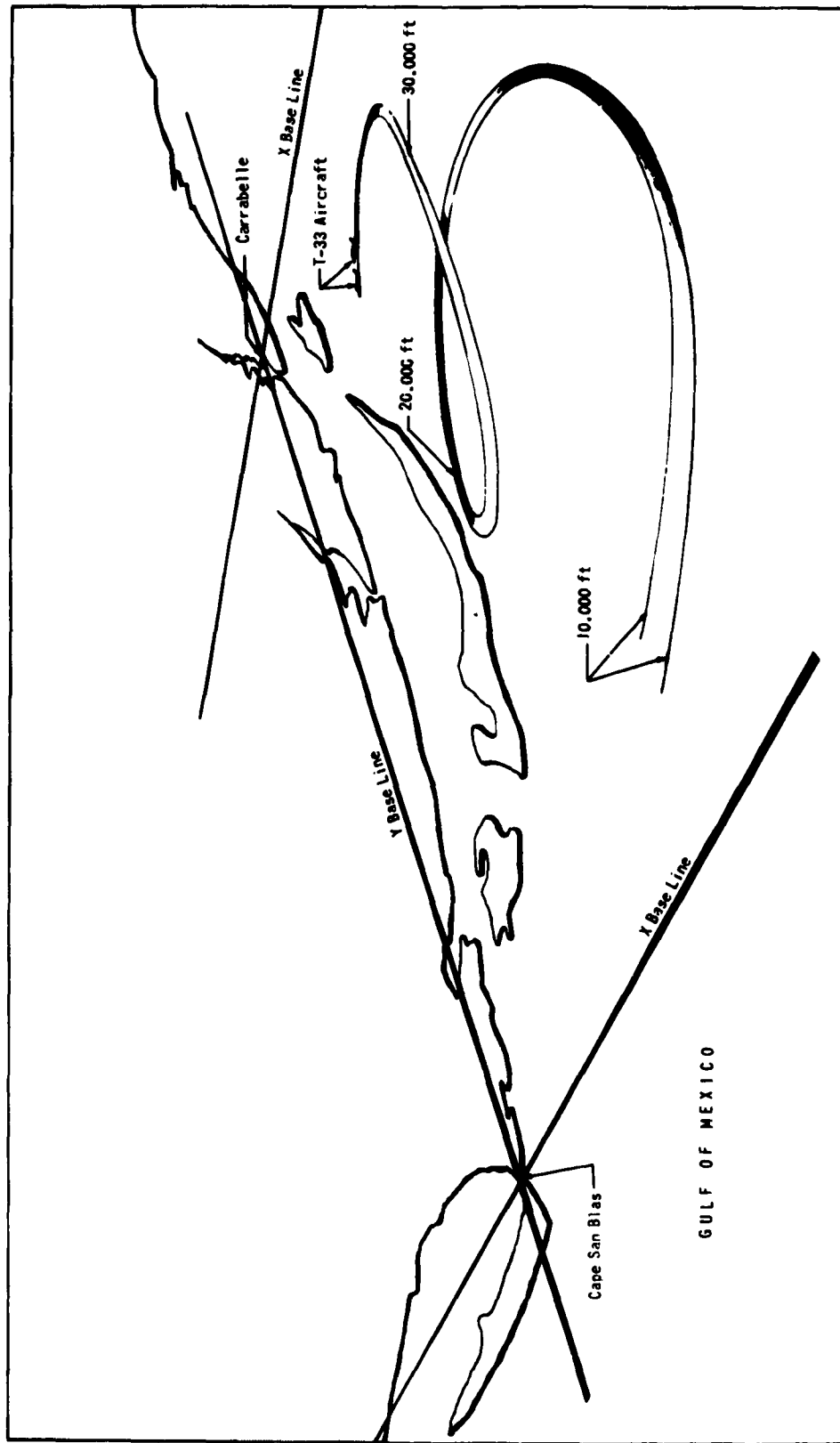


Fig. 10: Flight Profile for System Acquisition Time and Frequency Cross-Talk Test

TABLE 1. SYSTEM ACQUISITION TIME DATA

Site	Vehicle	X Servo (sec)	Y Servo (sec)
San Blas	Interceptor	0.6	0.6
	Target	0.7	0.7
	Rocket	0.6	0.6
Carrabelle	Intercept, on	0.6	0.6
	Target	0.7	0.7
	Rocket	0.8	0.8

The test was conducted in two phases. The first phase procedures were identical to the system acquisition time procedures which used three frequency sources; the second phase utilized two MATTS frequency sources (one in each of two aircraft). For the second phase, the lag aircraft carried the steady source, and the lead aircraft carried the source that was cycled from antenna to dummy load, producing periods of data and periods of silence.

**RESULTS.** The computer sample-by-sample listing of the trajectories indicated no observable interference. The data developed in a smooth manner, and the cycling appeared to have no effect. Data acquired during one frequency switch at 30,000 ft in each of the phases of this test are shown in Tables 2 and 3. Table 2 shows data acquired when the frequencies (221 Mc and 225 Mc) were being switched, and the 224 Mc frequency was on constantly. As can be seen in the table, the data progresses smoothly with no apparent deviations.

Table 3 shows the data acquired when the 225Mc source was being cycled from the dummy load to the antenna, thereby producing periodic data. The transition period before reacquisition is shown in samples 44170 and 44181. The data for the trajectory of the constant source indicate no serious deviations or interference. The data in Tables 2 and 3 are representative of the data accumulated during this test and indicate no frequency cross-talk.

#### SYSTEM TRACKING ACCURACY

The tracking accuracy of the MATTS apparently is affected by the homogeneity of the antenna fields and the amount of surrounding area obstruction to the antenna fields of view. During the testing period, the

TABLE 2. TRACKING DATA AT 30,000 FT DURING FREQUENCY CROSS-TALK TEST - THREE MATTS SOURCES

Sample No.	Interceptor (221 Mc)			Target (224 Mc)			Rocket (225 Mc)			Remarks
	X (ft)	Y (ft)	Z (ft)	X (ft)	Y (ft)	Z (ft)	X (ft)	Y (ft)	Z (ft)	
35141				178941	53136	30781	177080	38051	30826	221 Mc off
42				178928	53116	30774	177078	38032	30822	
43				178910	53094	30768	177070	38011	30815	
44				178896	53073	30757	177067	37989	30811	
45				178882	53053	30758	177063	37969	30815	
46				178870	53033	30747	177063	37950	30812	
47				178854	53012	30740	177059	37929	30816	
48				178845	52992	30736	177062	37911	30817	
49				178829	52973	30733	177061	37890	30824	
50				178817	52953	30729	177059	37872	30827	
51				178803	52933	30733	177057	37852	30834	
52				178790	52913	30728	177057	37832	30855	
53				178777	52895	30724	177056	37814	30653	
54				178764	52875	30733	177056	37795	30669	
55				178752	52855	30729	177057	37776	30651	
56	97868	20911	32882	178739	52836	30724	177059	37759	30811	Begin switch
57	116423	24861	678	178723	52818	30722	177056	37741	30795	
58	99979	21338	29355	178708	52798	30718	177069	37726	30740	225 Mc off, begin reacquisition
59	117650	25097	5469	178691	52780	30712	177137	37726	30466	
60	226773	48265	102028	178675	52760	30711	177209	37724	30193	
61	311843	66454	172832	178658	52740	30709	177280	37722	29928	
62	311299	66303	172374	178643	52721	30712	177354	37721	29652	
63	311274	66259	172312	178627	52700	30717	209526	44512	10521	Locked on 221 Mc, 225 Mc off
64	226104	18104	101657	178611	52681	30727	209609	44539	10580	
65	226113	18078	101658	178598	52662	30742	209699	44536	10637	
66	226129	48054	101666	178582	52644	30748	209783	44532	10696	
67	226127	18026	101671	178568	52624	30760	209868	44529	10750	
68	226125	47998	101671	178553	52604	30779	209954	44525	10804	
69	226130	47974	101678	178540	52585	30784	210038	44521	10862	
70	226131	47947	101687	178528	52566	30793	210123	44518	10917	
71	177013	37511	31160	178515	52546	30806				
72	177012	37491	31158	178502	52527	30820				
73	177008	37469	31163	178491	52508	30852				
74	177008	37448	31181	178476	52487	30855				
75	177006	37427	31193	178463	52467	30855				
76	176994	37404	31193	178453	52447	30863				Locked on 221 Mc, 225 Mc off
77	176990	37383	31224	178439	52427	30873				
78	176986	37362	31247	178428	52406	30886				
79	176976	37340	31253	178420	52386	30898				
80	176976	37320	31277	178408	52365	30909				
81	176974	37301	31311	178397	52345	30920				
35182	176965	37280	31322	178385	52324	30929				

TABLE 3. TRACKING DATA AT 30,000 FT DURING FREQUENCY CROSS-TALK TEST - TWO MATTS SOURCES

Sample No.	Target (224 Mc)			Rocket (225 Mc)			Remarks
	X (ft)	Y (ft)	Z (ft)	X (ft)	Y (ft)	Z (ft)	
44165	236605	74227	30386	1634013	1856409	637339	225 Mc on dummy load
166	236591	74256	30384	276873	434898	94206	
167	236579	74281	30391	117408	148759	37245	
168	236562	74313	30390	152383	126862	6224	
169	236551	74343	30386	163100	135810	26947	
170	236538	74370	30389	187320	111341	24503	Switch from dummy load to antenna Start of system reacquisition
171	236526	74398	30388	239440	95334	48839	
172	236514	74424	30398	239412	95366	48827	
173	236502	74452	30396	239390	95400	48817	
174	236491	74478	30395	239364	95431	48811	
175	236482	74506	30399	258166	85479	-19454	Locked on 225 Mc
176	236471	74453	30399	258151	85508	-19459	
177	236462	74560	30396	258137	85535	-19435	
178	236451	74586	30413	258147	85550	-19691	
179	236440	74613	30421	258140	85574	-19724	
180	236431	74641	30420	258135	85596	-19741	
181	236418	74667	30424	232290	77082	30062	
182	236410	74695	30432	232277	77105	30045	
183	236399	74722	30434	232268	77129	30030	
184	236388	74750	30434	232213	77187	29972	
185	236378	74778	30431	232217	77210	29979	
186	236369	74806	30431	232192	77222	29922	
187	236357	74833	30424	232193	77244	29938	
188	236348	74863	30417	232194	77268	29947	
189	236336	74891	30412	232191	77291	29970	
190	236327	74920	30409	232190	77316	29972	
191	236315	74949	30403	232183	77342	29984	
192	236304	74976	30400	232175	77368	30005	
193	236295	75006	30407	232168	77396	30011	
194	236284	75035	30395	232160	77424	30019	
195	236275	75063	30400	232154	77452	30023	
196	236262	75090	30399	232145	77480	30015	
197	236252	75119	30387	232137	77509	30021	
198	236241	75148	30373	232128	77539	30016	
199	236231	75176	30370	232121	77568	30019	
200	236219	75205	30354	232115	77596	30011	
201	236212	75234	30343	232112	77627	30002	
44202	236204	75264	30330	232105	77655	29994	

antenna fields and the surrounding areas were leveled. This physical change in the surrounding ground areas enhanced the quality of the MATT data. Because the change was implemented while the test was in progress, data obtained for spatial position accuracy and scoring accuracy after the change should not be compared with the tracking accuracy data, which were accrued before the change.

**PROCEDURE.** One of the chief assets of the MATTS is its ability to track three airborne vehicles simultaneously. To assess the accuracy of the MATTS tracks, one T-33 aircraft carried two MATTS frequency sources, one transmitting from a UHF quarter-wave stub antenna and the other on a dummy load. These frequencies were alternated from antenna to dummy load by an electronic switching device over a specified flight path (Fig. 11). The device incorporated an intervalometer so that the interval between the switches could be arbitrarily set at a desired period of time, dependent upon the speed of the aircraft. When the aircraft traversed a mile of ground track, the frequencies were switched. Because both frequencies originated from the same antenna and the same aircraft, the trajectory of the aircraft should have been constant. The difference, if any, in the projected trajectories for each source, for any one frequency switch, was the tracking error.

To analyze the tracking errors, two points on the projected mean tracks corresponding to the midpoint in time between the last data point before a frequency switch and the first point following the switch were determined. The line joining these points was the shift in position, and thus its X and Y components, designated  $\Delta X$  and  $\Delta Y$ , were the corresponding shifts in X and Y.

**RESULTS.** The interchannel tracking errors as assessed by the method just described are shown in Fig. 12 and in Table 4. The values presented are the mean values of the tracking data error; these were used for all conclusions drawn concerning the tracking accuracy of the MATTS. In Fig. 12 the SAGE drone track is shown divided into eight general areas which were employed to facilitate analysis and discussion of specific areas of interest. The error is specified in each area at altitudes of 25,000 and 40,000 ft. In areas 3, 4, 5, 6, and 7 the errors appear negligible, or small enough not to affect the data adversely. However, the tracking errors in area No. 2 are marginal; at 25,000 ft altitude they are beyond the limits of usable data, but at 40,000 ft they probably would not be objectionable. In areas 1 and 8 the errors appear too large for MATTS applications.

Samples of data from areas 1 and 3 assessed by the method described are shown in Figs. 13 and 14, respectively. As can be seen, each

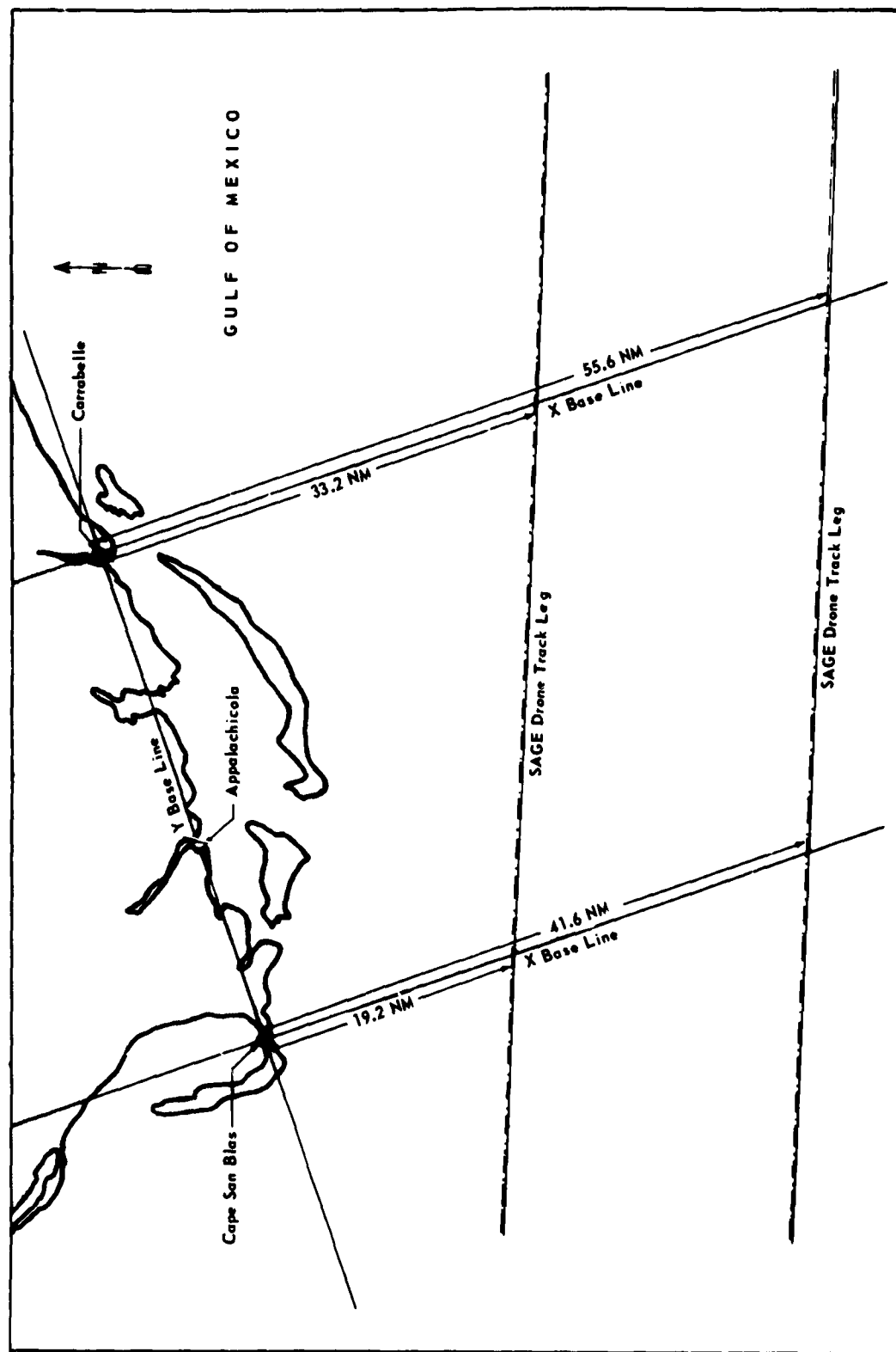


Fig. 11: Tracking Accuracy Flight Profile

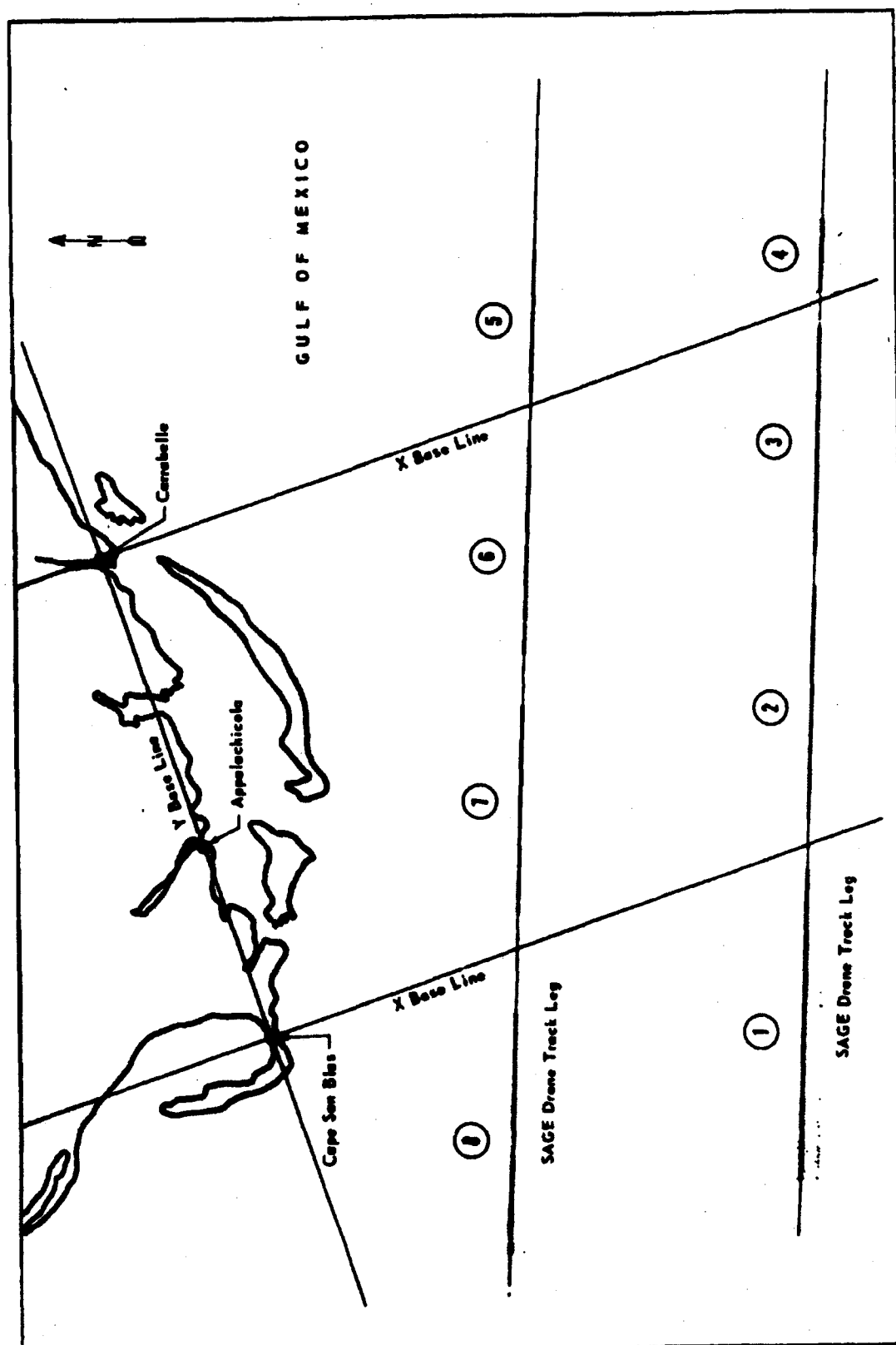


Fig. 12: Tracking Accuracy Investigation Areas of SAGE Drone Pattern

TABLE 4. INTERCHANNEL TRACKING ACCURACY DATA

SAGE Drone Track Area No.	Altitude (ft)	$\Delta X$			$\Delta Y$		
		Deviation (ft) Range (ft)	Value	Percent Deviation	Deviation (ft) Range (ft)	Value	Percent Deviation
1	25,000	$\frac{390}{206700}$	$150 \cdot 10^{-5}$	0.15	$\frac{170}{143300}$	$100 \cdot 10^{-5}$	0.10
	40,000	$\frac{145}{203600}$	$71 \cdot 10^{-5}$	0.07	$\frac{100}{142000}$	$70 \cdot 10^{-5}$	0.07
2	25,000	$\frac{155}{290800}$	$50 \cdot 10^{-5}$	0.05	$\frac{105}{65000}$	$130 \cdot 10^{-5}$	0.13
	40,000	$\frac{120}{287800}$	$41 \cdot 10^{-5}$	0.04	$\frac{54}{68900}$	$75 \cdot 10^{-5}$	0.08
3	25,000	$\frac{190}{325600}$	$58 \cdot 10^{-5}$	0.06	$\frac{85}{154300}$	$55 \cdot 10^{-5}$	0.06
	40,000	$\frac{130}{315500}$	$40 \cdot 10^{-5}$	0.04	$\frac{50}{147500}$	$32 \cdot 10^{-5}$	0.03
4	25,000	$\frac{9}{329600}$	$5 \cdot 10^{-5}$	0.005	$\frac{6}{103200}$	$5 \cdot 10^{-5}$	0.005
	40,000	$\frac{130}{346900}$	$36 \cdot 10^{-5}$	0.04	$\frac{52}{243800}$	$21 \cdot 10^{-5}$	0.02
5	25,000	$\frac{35}{195900}$	$10 \cdot 10^{-5}$	0.01	$\frac{7}{226600}$	$0.3 \cdot 10^{-5}$	0.0003
	40,000	$\frac{12}{203300}$	$5 \cdot 10^{-5}$	0.005	$\frac{17}{248500}$	$3 \cdot 10^{-5}$	0.003
6	25,000	$\frac{50}{165000}$	$30 \cdot 10^{-5}$	0.03	$\frac{25}{162500}$	$15 \cdot 10^{-5}$	0.02
	40,000	$\frac{45}{161800}$	$23 \cdot 10^{-5}$	0.023	$\frac{23}{167700}$	$11 \cdot 10^{-5}$	0.01
7	25,000	$\frac{8}{122000}$	$7 \cdot 10^{-5}$	0.007	$\frac{5}{56100}$	$9 \cdot 10^{-5}$	0.009
	40,000	$\frac{0}{122000}$	0	0	$\frac{0}{78500}$	0	0
8	25,000	$\frac{170}{53000}$	$330 \cdot 10^{-5}$	0.33	$\frac{72}{97000}$	$75 \cdot 10^{-5}$	0.08
	40,000	$\frac{114}{45500}$	$250 \cdot 10^{-5}$	0.25	$\frac{143}{121225}$	$120 \cdot 10^{-5}$	0.12

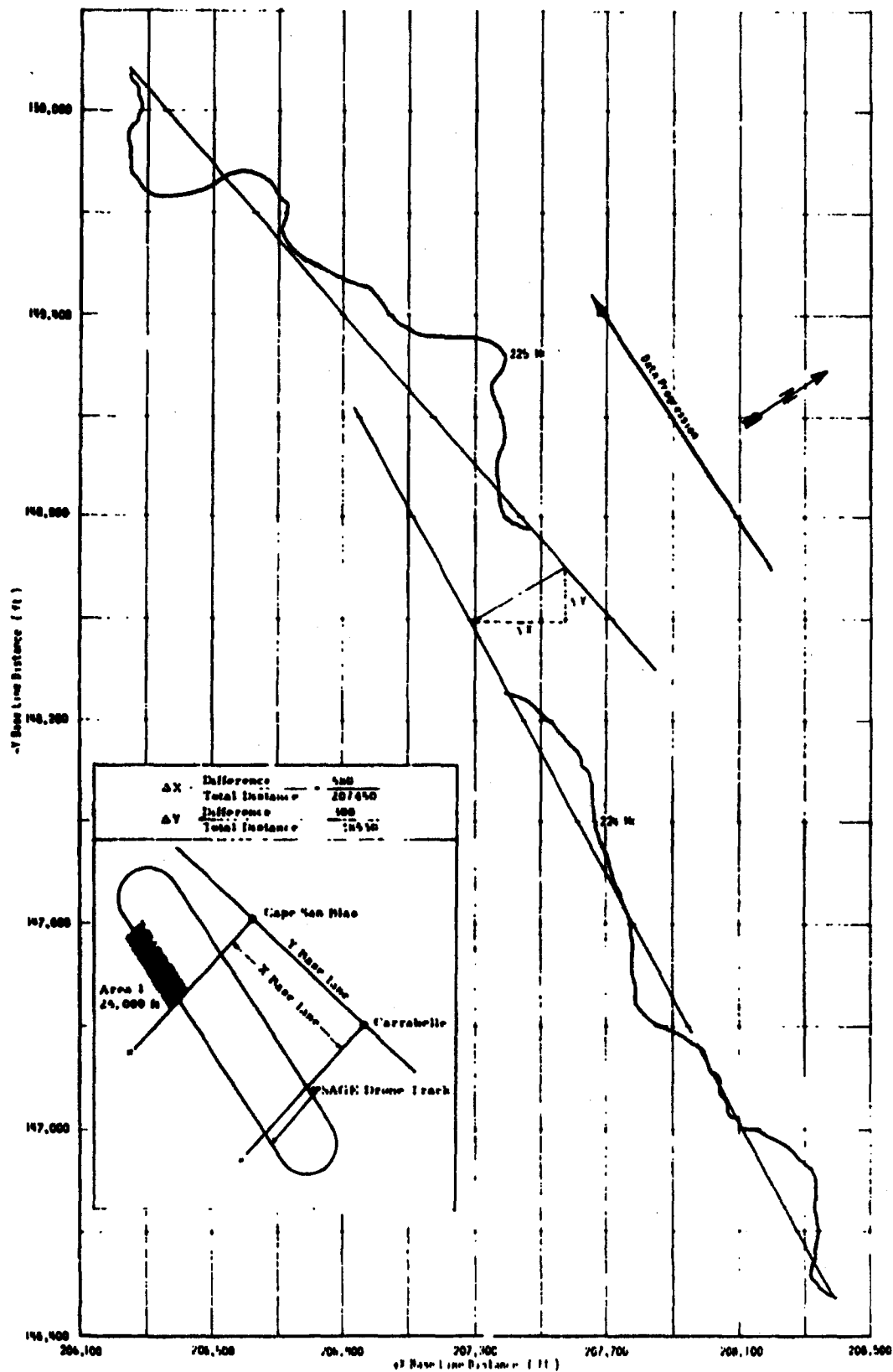


Fig. 13: Tracking Error - Area 1, SAGE Drone Pattern

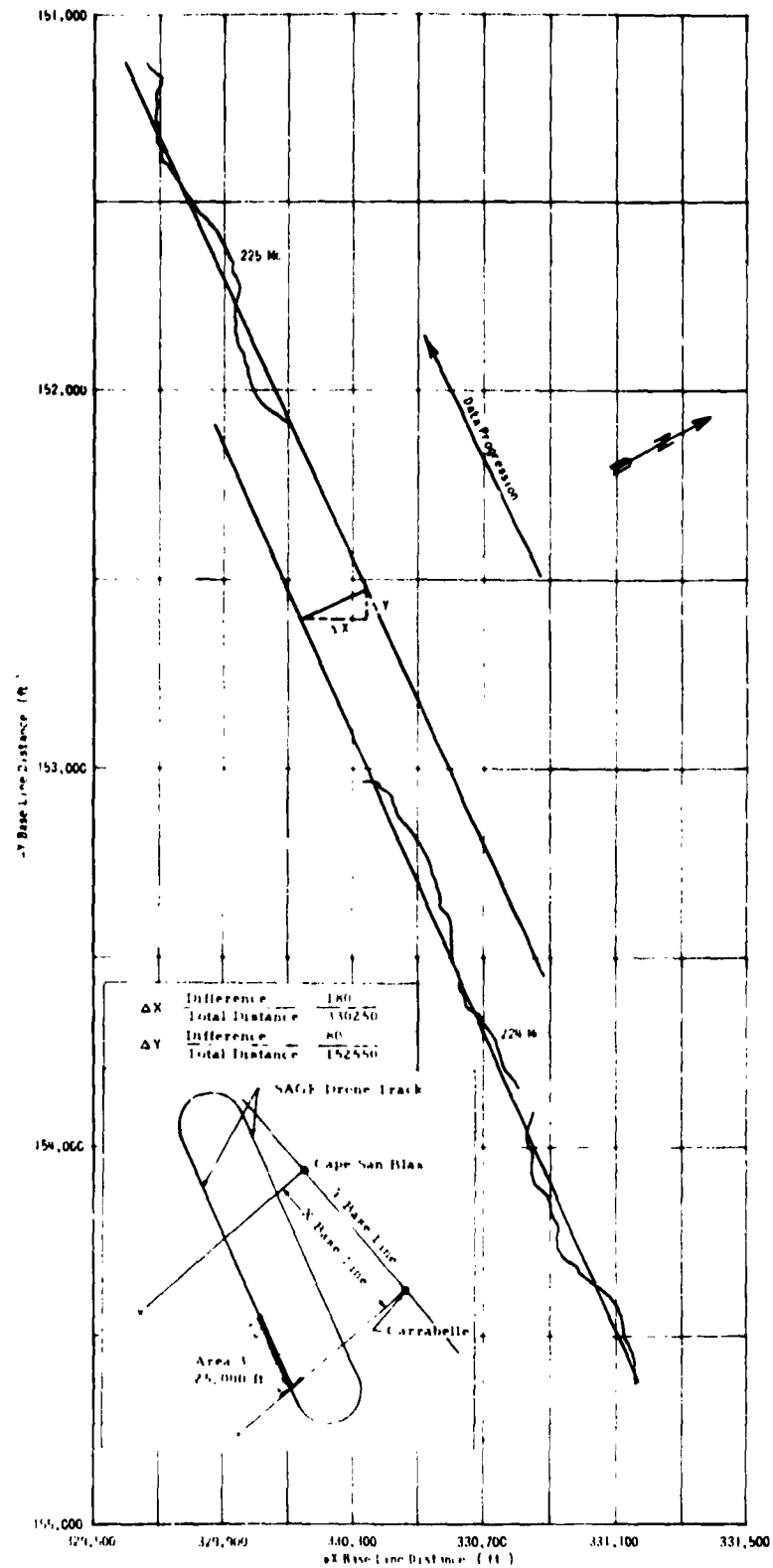


Fig. 14: Tracking Error - Area 3, SAGE Drone Pattern

trajectory varies about a mean path, and the mean paths are not continuous straight lines. Also, the angle of deviation from the straight line seems to vary from one data sample to another. The deviations from the straight line trajectories are apparent in the presentation of the flight path data in the figures. In Fig. 13 the mean paths would intersect if extended, while the mean paths are almost parallel in Fig. 14. Because of these varying conditions at every data point, it was not possible to accomplish an exact analysis of the differences between the two projected trajectories.

**DISCUSSION OF TRACKING ERRORS.** Factors contributing to the overall system tracking error included (1) multipath, (2) low antenna look angles, (3) misalignment of the Y base line, (4) unstable calibration, (5) modulation effects, (6) microwave data link, and (7) data reduction.

**Multipath.** A multipath error is due to interference between the free-space wave and the ground-reflected wave as the two components arrive at the antennas in the antenna fields. The large errors in areas 1 and 3 (see Fig. 12) may be attributed in part to multipath errors at both sites, a factor which seems to be inherent in the system antenna fields. To compute the field response correctly, it is necessary to calculate the continuous wave data and the multipath waves separately and to add them in correct phase relationship. The phase and amplitude of the reflected wave are determined by the geometry of the path and the change in magnitude and phase due to ground reflection. For vertically polarized antennas, such as those utilized by the MATTS, the reflection coefficient and the phase shift vary appreciably with the reflection constants of the reflectors and the antenna look angles.

Other factors which may cause a multipath error are abnormal water vapor or temperature gradients, irregularities in the ground plane around the antenna fields and in the plane of the antenna field itself, and obstructions to the antenna fields of view such as buildings, trees, etc. However, because multipath errors were not explicitly determined by this test, no definite conclusions can be drawn as to their effect upon the accuracy of the system.

**Antenna Look Angles.** Another error factor that may be attributable to the antenna fields at the AME sites is the antenna look angle. At low altitudes, the look angles for the antennas in each field are system limiting factors. If these limits are exceeded, the data are degraded accordingly. The lowest limiting look angle cannot be accurately defined from the data accrued on this test, but it is approximately  $4^{\circ}$  to  $7^{\circ}$  above the horizon. While flying sorties at 80 NM over the water range parallel to the Y base line, it was observed that the tracking data were so poor at

25,000 ft (elevation angles between  $2\frac{1}{2}^\circ$  and  $3^\circ$ ) that no scoring accuracy evaluation could be accomplished.

Y Base Line Misalignment. The Y base lines for the two AME sites are theoretically intersecting straight lines. By flying across the base line and having the sites signify when they saw the crossing, what appeared to be a discontinuity was observed. The two sites saw the aircraft cross the base line at two separate times when they should have observed the crossing simultaneously. However, the extent to which this error affects the tracking accuracy was not explored during this test.

Physical correction of the misalignment of the Y base line would require relocation of all the antennas in one or both of the antenna fields since the base line has as its determining points the center of the X and Y base lines of the antenna arrays at each site, and the arrays must be perpendicular. Because the antennas in each field are semi-permanently installed, this type of correction would necessarily be an expensive one. However, changing the computer mathematics would result in the same correction at much less expense.

Unstable Calibration. After inclement weather, the pre- and post-mission calibrations differed by significant amounts. Variations in the level of the water table beneath the antenna fields was suspected of being the cause. This difference in calibrations added a varying error that increased during a mission. Thus, the balancing of errors for each base line at each site was correspondingly erroneous, and the direction cosines obtained thereafter incorporated the error. The measured positions obtained as the error increased were as different from each other as they were from the true positions. No explicit study was accomplished to assess this error during this test, but the calibration records of the operating crew for the Cubic Corporation verify the observed calibration changes. System accuracy is dependent upon calibration as one of its determining factors. The accuracy between September and October testing improved. Either the long dry spell or closer calibration techniques, or both, may have contributed to the improvement.

Modulation Effects. One of the probable factors that was not investigated was the effect of modulation upon the launch and burst data samples. The modulation may induce an error that is at the present time unaccounted for.

Microwave Data Link. Microwave data transmissions at certain periods during the day had a definite effect upon the integrity of the data received from each of the sites.

Data Reduction. During the processing of data collected during the test, it was found that some of the magnetic tapes from Tyndall were not compatible with the Eglin computer equipment. Data tapes that Eglin could not reduce were returned to Tyndall, and without fail, yielded data. This fact points out an incompatibility between either the method of recording data in the MATTS van and the computer circuitry at Eglin or the MATTS tapes and the data handling equipment at Eglin. This fact also creates a sense of doubt as to the quality of the data from the tapes that Eglin could reduce.

A problem does exist in time correlation of the MATTS data. The matts sample pulses and the MATTS time are derived from a 3000 cps oscillator within the MATTS equipment. The oscillator is not an ultra-stable item; therefore, any slight change in its frequency will affect the sample pulses and the timing. The sample pulses are not synchronized with WWV or EGTR time which makes it virtually impossible to correlate the MATTS data with the EGTR data.

Also, some difficulty was encountered in regards to the pulse levels on the MATTS magnetic tape which does affect the reduction of the data. A change in electronic gear in the tape handling system would improve the integrity of the pulse levels on the MATTS tapes. More explicit information may be obtained from Math Services Laboratory at Eglin AFB, Florida.

## SPACE POSITION ACCURACY

PROCEDURE. The overall error in any MATTS measurement incorporates an error known as space position error. At any one point in space, the true position coordinates ( $X_t$ ,  $Y_t$ ,  $Z_t$ ) differ from the MATTS measured coordinates ( $X_m$ ,  $Y_m$ ,  $Z_m$ ) by the space position error.

To determine the space position error of the MATTS, an instrumented T-33 aircraft was flown over a predetermined flight path (Fig. 15). A total of four passes were flown over this path, one east to west and one west to east at 25,000 ft altitude, and the same at 38,000 ft altitude.

A strobe light that flashed every four seconds was located on the right wing tip of the aircraft. Ballistic cameras located along the flight path of the aircraft at Cape San Blas, Appalachicola, and Carrabelle, Florida, photographed the light flashes and stars of intensity greater than or equal to the ninth magnitude. Utilizing the known position of the

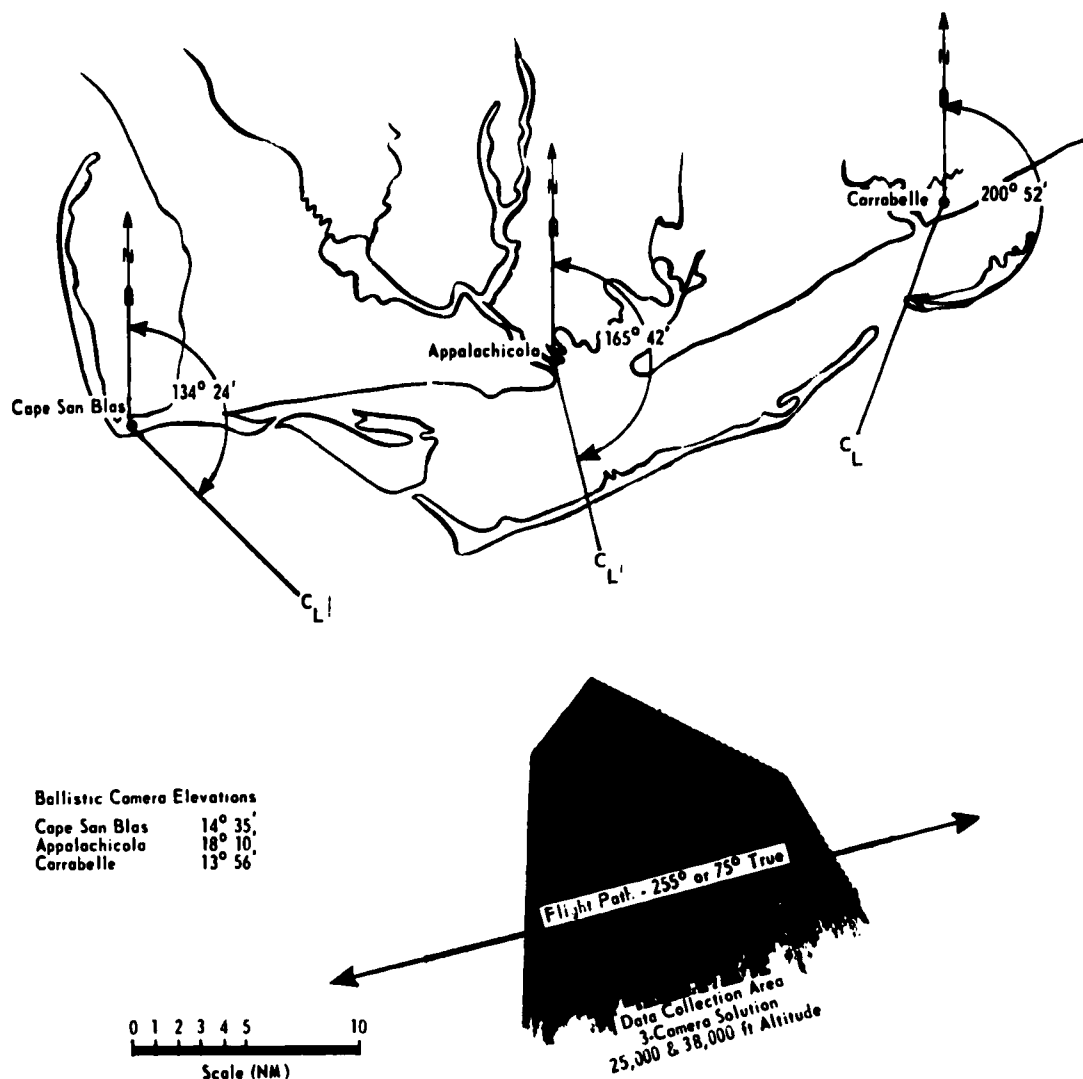


Fig. 15: Space Position Accuracy Flight Profile

stars and a method of triangulation from the ballistic camera plates to define the position of the aircraft, the true space position of the aircraft was determined.

A photosensor, located on the inside of the aircraft canopy, translated the strobe light flashes into electrical impulses. These impulses were utilized to modulate the MATTS tracking frequency, and the MATTS obtained the aircraft coordinates each time the light flashed. Using the ballistic camera data as the standard, the space position error of the MATTS was evaluated.

**RESULTS.** The measurements and calculated errors for the 50 data points accumulated are presented in Table 5. The table shows the ballistic camera and MATTS values for X, Y, Z and refraction-corrected values for the MATTS Z only. A refraction correction was used when

**TABLE 5. SPACE POSITION ACCURACY DATA - BALLISTIC CAMERAS (BC-4) VERSUS MATTS**

Ballistic Camera Time (WWV)	MATTS Time	X (ft)			Y (ft)			Z (ft)			Refraction Corrected MATTS Data (ft)	Z Error (ft)
		BC-4	MATTS	Error	BC-4	MATTS	Error	BC-4	MATTS	Error		
West to East Leg - 25,000 ft Altitude												
310211600	310211499	132072	132111	39	107468	107536	68	25431	26329	898	26175	744
310258400	310258499	131974	131976	2	110138	110200	62	25404	26018	614	25864	460
310305300	310305499	131901	131894	-7	112817	112862	45	25369	26002	633	25848	479
310352300	310352499	131842	131863	21	115508	115575	67	25330	25908	578	25754	424
310399500	310399999	131780	131788	8	118209	118302	93	25291	26031	740	25878	587
310447000	310446999	131709	131699	-10	120934	120987	53	25248	25949	701	25796	548
310494900	310494999	131666	131664	-2	123682	123759	77	25216	25917	701	25764	548
310571000	310571999	131612	131585	-27	128056	128180	124	25192	25866	674	25715	523
East to West Leg - 25,000 ft Altitude												
333466100	333464999	131722	131759	37	126476	126530	54	25324	26011	687	25860	536
333513300	333513499	131621	131645	24	124014	124012	-2	25327	26068	741	25916	589
334007600	334007499	131496	131506	10	119072	119059	-13	25260	26055	795	25903	643
334054500	334054499	131423	131453	30	116586	116588	2	25278	26051	773	25898	620
334101300	334101499	131361	131420	59	114139	114146	7	25342	26040	698	25886	544
334165100	334104999	131296	131331	35	110801	110821	20	25327	25984	657	25830	503
334230300	334230499	131156	131171	15	107385	107362	-23	25365	26159	794	26007	642
334276900	334276999	131018	131080	62	104948	104953	5	25389	26123	734	25971	582
334323400	334323499	130947	131003	56	102516	102540	24	25401	26057	656	25905	504
334369600	334364999	130894	130922	28	100117	100117	0	25451	26148	697	26083	632
334430900	334430999	130802	130871	69	96947	96940	-7	25488	26271	783	26121	633
334477100	334476999	130757	130822	65	94557	94564	7	25480	26279	799	26130	650
334523400	334524499	130721	130771	50	92166	92075	-91	25469	26245	776	26097	628
335098600	335098499	130440	130493	53	83081	83072	-9	25527	26292	765	26149	622
335145100	335144999	130356	130401	45	80688	80673	-15	25527	26346	819	26205	678
West to East Leg - 38,000 ft Altitude												
423447100	423447019	131812	131850	38	83714	83717	3	38816	39432	616	39305	489
423503200	423503019	131809	131843	34	87431	87451	20	38794	39408	614	39279	485
423545600	423546019	131800	131825	25	90244	90299	55	38789	39336	547	39207	418
424001900	424002019	131781	131808	27	93970	94009	39	38807	39380	573	39249	442
424058200	424057519	131794	131814	20	97681	97659	22	38827	39386	559	39254	427
424114000	424114519	131813	131834	21	101358	101406	48	38813	39444	631	39311	498
424214400	424214519	131778	131813	35	107979	108016	37	38730	39331	601	39197	467
424256700	424256519	131763	131789	26	110777	110793	16	38704	39268	564	39135	431
424298700	424298519	131743	131766	23	113560	113579	19	38669	39224	555	39090	411
424367500	424367019	131661	131697	36	118122	118155	33	38628	39168	540	39035	407
424512000	424512019	131416	131458	42	127756	127714	-42	38606	39113	507	38982	376
East to West Leg - 38,000 ft Altitude												
441251000	441250887	130921	130972	51	130355	130385	30	38561	39032	471	38902	441
441292300	441292387	130800	130842	42	127942	127968	26	38555	39007	452	38877	322
441334100	441333887	130716	130757	41	125496	125533	37	38557	39029	472	38898	341
441375500	441375387	130670	130699	29	123074	123089	15	38556	39101	545	38970	414
441417600	441417387	130579	130622	43	120616	120646	30	38608	39136	528	39004	396
441459500	441459387	130513	130560	47	118180	118224	44	38677	39220	543	39088	411
441501300	441501387	130448	130498	41	115763	115775	12	38711	39223	512	39091	380
442003900	442003887	130212	130266	54	109819	109831	12	38742	39303	561	39171	429
442045800	442045887	130128	130183	55	107381	107395	14	38743	39306	563	39174	431
442088400	442088387	130037	130113	76	104915	104917	22	38744	39370	627	39222	479
442130700	442130387	129953	130026	73	102457	102492	35	38757	39365	608	39234	477
442173400	442173387	129874	129955	81	99981	99996	15	38768	39367	599	39237	469
442334300	442334387	129638	129709	71	90655	90649	-6	38858	39452	594	39325	467
442376400	442376387	129551	129626	75	88228	88228	0	38886	39458	572	39331	445
442460200	442460387	129313	129389	76	83387	83363	-24	38871	39477	606	39353	482
442502300	442502387	129261	129306	45	80946	80940	-6	38844	39420	576	39297	453

it was found that the bending of the MATTS signals by the lower atmosphere was causing the MATTS altitude data to be significantly different from the ballistic camera data. The refraction correction for the MATTS data had an insignificant effect upon the X and Y portions of the data, but reduced the values of the Z data by an average of 142 ft. Incorporating the refraction correction into the MATTS data made the results comparable to those reported for the original MATTS configuration.

Graphical presentations of the X, Y, Z coordinates of all the assessable data points on all four passes are shown in Figs. 16, 17, 18, and 19. The coordinates for each point are plotted against WWV time. This was done because some of the data points were unassessable, and because the strobe light was shut off for one or two flashes on each pass for data reduction purposes. Plotting the data in this chronological manner eliminated any discontinuities in the presentation. The graphs clearly show the difference between the ballistic camera data and the MATTS data. The errors in the direction cosines produced relatively small errors in X and Y, but large errors in Z.

A statistical analysis of the data is presented in Table 6. The standard deviations of the data decrease with an increase in altitude. This fact underlines the effect of an increasing antenna look angle and verifies the results of the tracking error test.

## SCORING ACCURACY EVALUATION

**PROCEDURE.** The MATTS was designed to track three airborne vehicles (in a typical intercept) simultaneously, and at rocket burst to measure the vector miss distance (target to rocket) and the vector escape distance (interceptor to rocket). During an intercept, when the rocket is launched from the interceptor, the interceptor MATTS frequency (221 Mc) is modulated. The modulation indicates rocket launch to the MATTS equipment and is termed the launch signal. When the rocket explodes, the MATTS rocket frequency (225 Mc) is modulated, giving the MATTS equipment a burst signal. In order for MATTS to accomplish the necessary computations to obtain the miss and escape distances, the launch and burst signals (respectively) must be received. During this test the modulated signals were produced manually via controls installed in the T-33 aircraft cockpits.

To determine the MATTS scoring accuracy, three instrumented T-33 aircraft were used to simulate the three vehicles. They were flown over predetermined flight paths at various altitudes. Two of the aircraft were flown abreast, approximately 60 ft apart, while the third

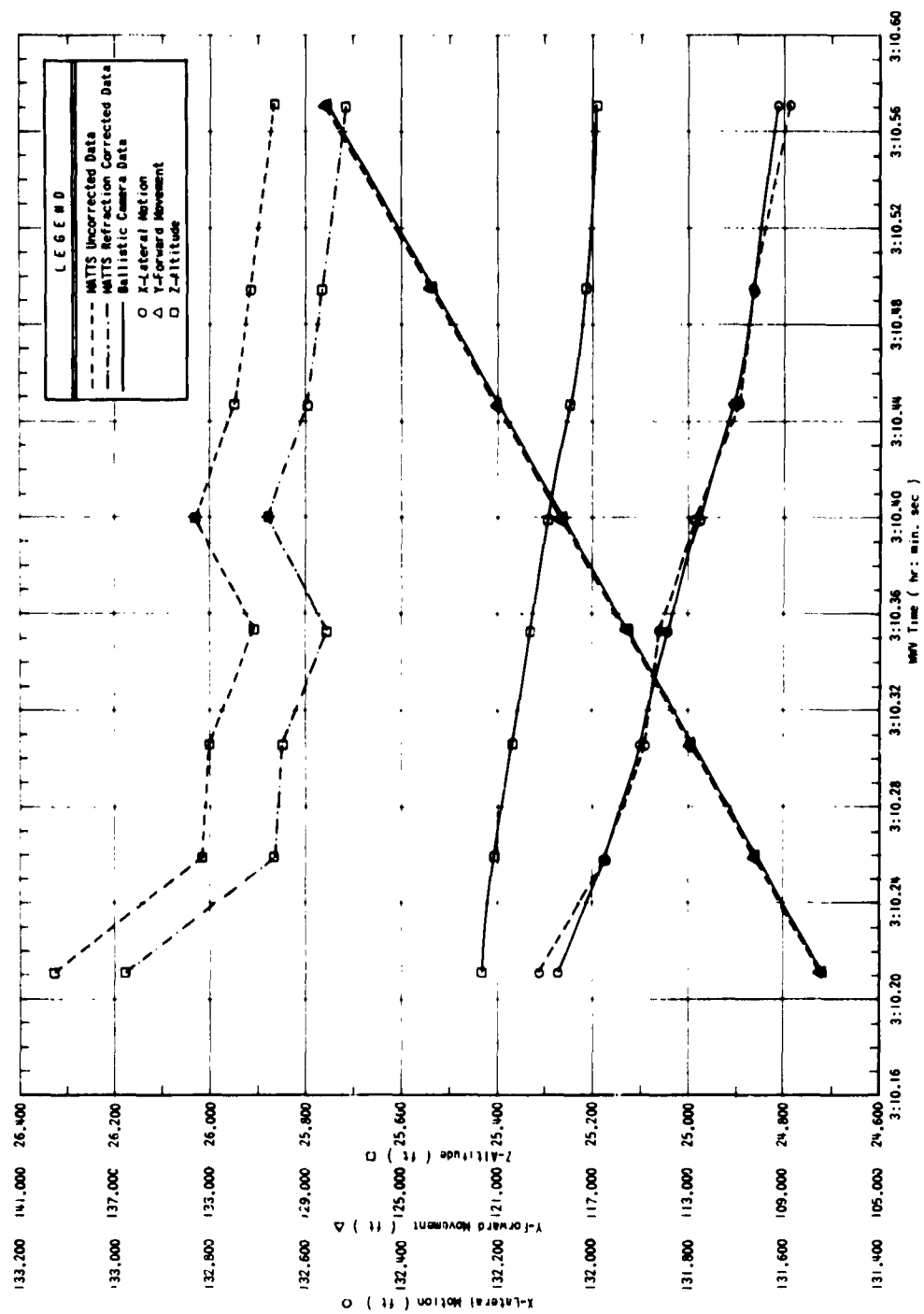


Fig. 16: Ballistic Camera and MATTS Coordinates (X, Y, Z) for First Pass at 25,000 ft

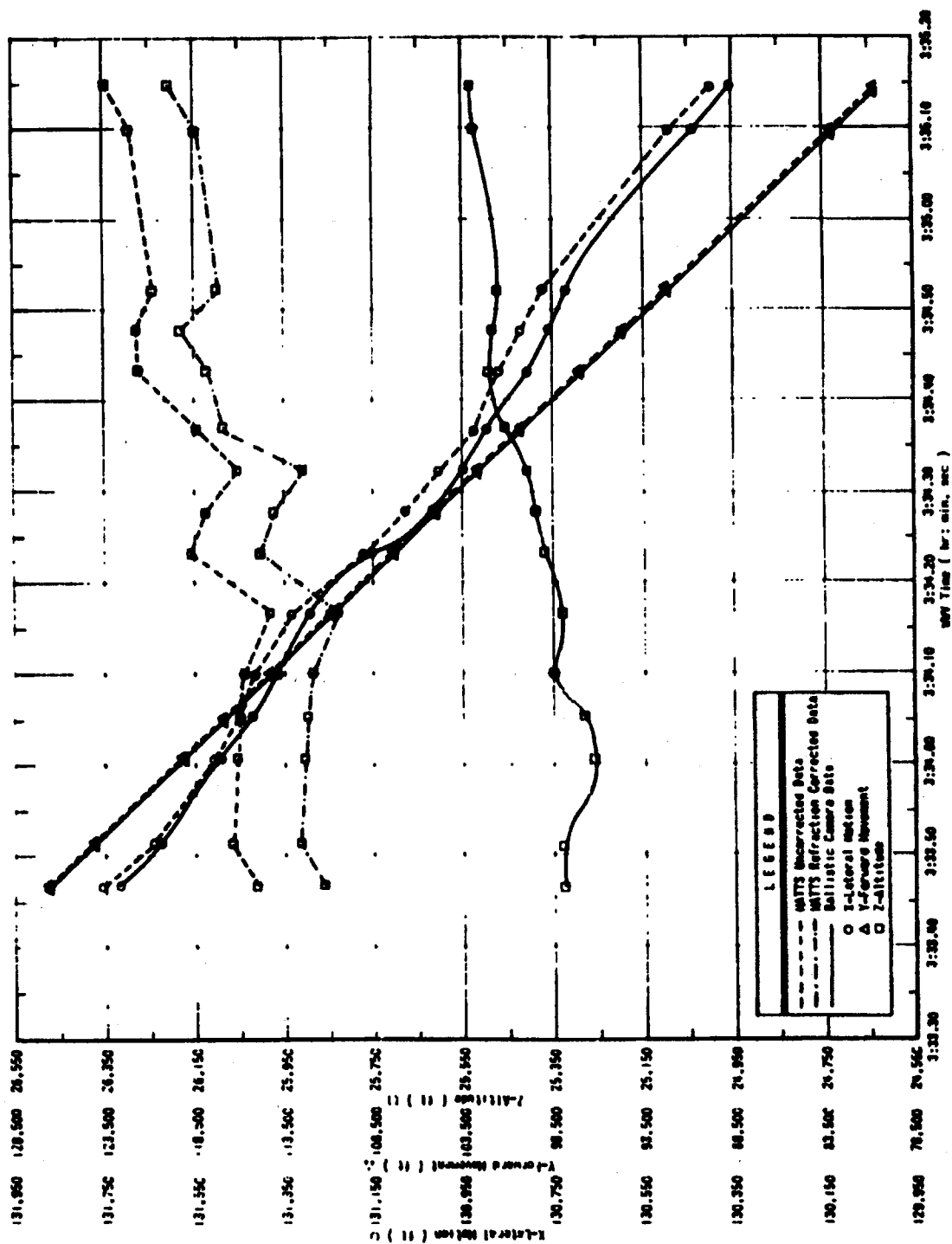


Fig. 17: Ballistic Camera and MATTS Coordinates (X, Y, Z) for Second Pass at 25,000 ft

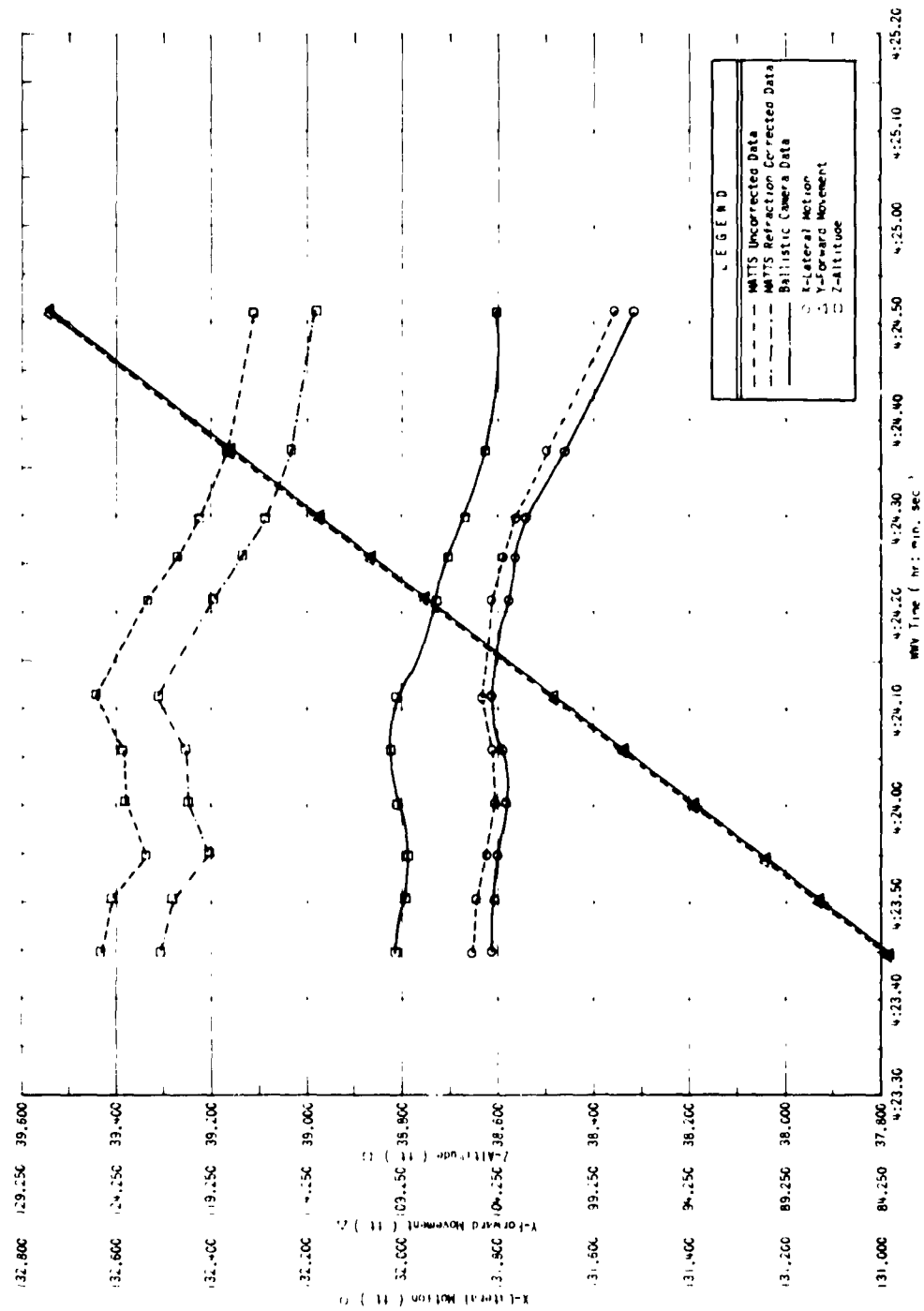


Fig. 18: Ballistic Camera and MATTS Coordinates (X, Y, Z) for First Pass at 38,000 ft

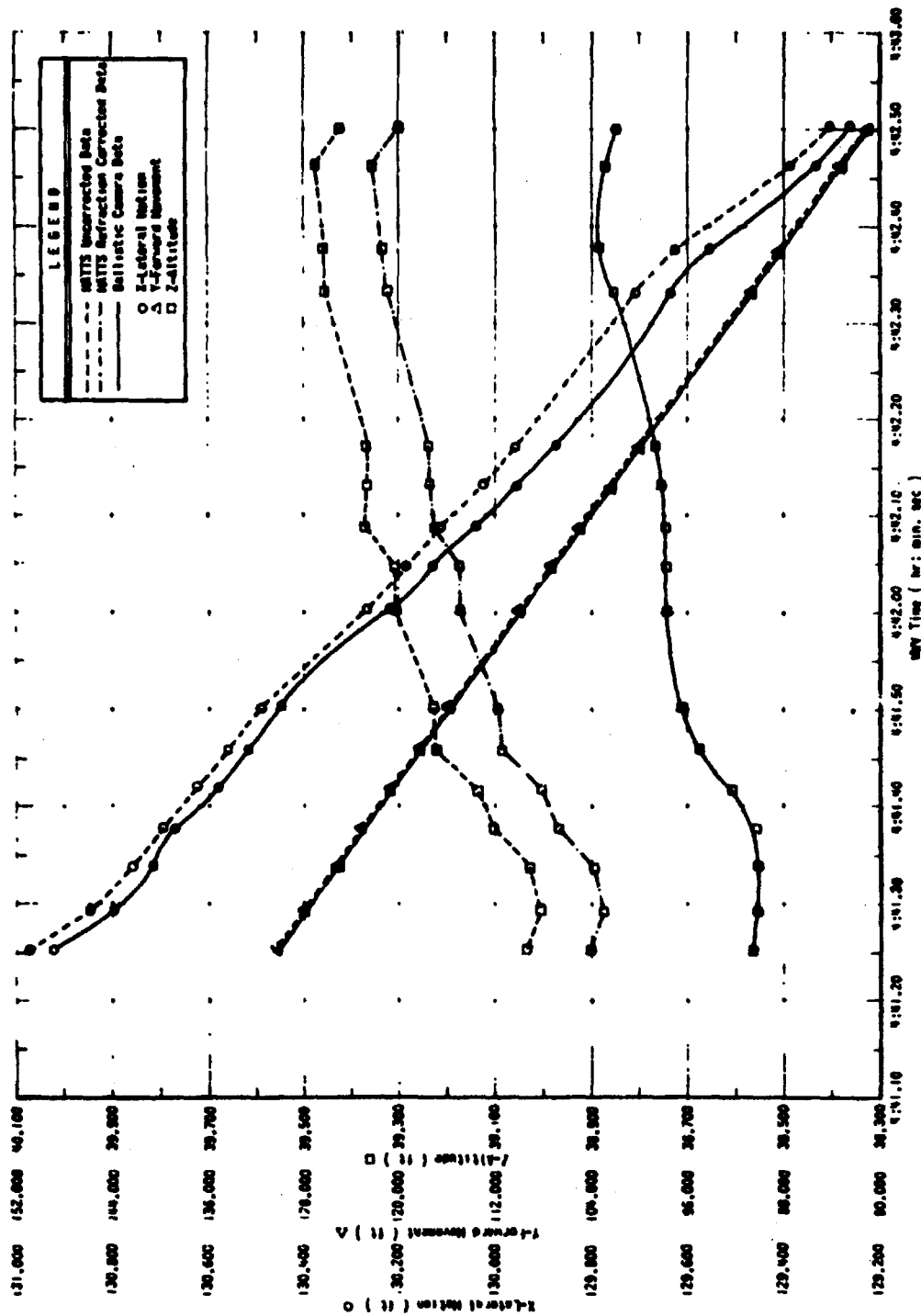


Fig. 19: Ballistic Camera and MATTS Coordinates (X, Y, Z) for Second Pass at 38,000 ft

TABLE 6. SPACE POSITION ERROR ANALYSIS

Altitude and Direction	Coordinate	No. of Samples N	Algebraic Sum of Errors $\Sigma \Delta$ (ft)	Mean $\bar{x} = \frac{\Sigma \Delta}{N}$ (ft)	Sum of Squares of Errors $\Sigma \Delta^2$ (ft <sup>2</sup> )	Standard Deviation Squared $s^2$ (ft <sup>2</sup> )	Standard Deviation s (ft)	Probable Error of Standard Deviation 1.6 s (ft)
25,000 ft West to East Pass No. 1	X	8	21	2.625	2912	105.114	10.25	16.5
	Y	8	589	73.625	41115	625.696	25	40.0
	Z	8	5539	692.375	492811	2663.676	51.63	82.6
25,000 ft East to West Pass No. 2	X	15	638	42.533	11960	186.160	13.66	21.9
	Y	15	41	2.733	11851	829.635	28.8	46.0
	Z	15	11171	744.733	836416	55792.804	236.2	377.9
10,000 ft West to East Pass No. 3	X	11	327	29.727	10785	56.118	7.5	12.0
	Y	11	326	29.636	11792	593.951	24.37	39.0
	Z	11	6392	581.091	36396.01	1199.891	34.64	55.4
10,000 ft East to West Pass No. 4	X	16	880	55.000	52000	221.000	14.87	23.8
	Y	16	256	16.000	672	111.733	10.57	16.9
	Z	16	8879	554.938	491017	2806.296	53.03	84.8
25,000 ft Passes 1 and 2 Combined	X	23	662	28.783	11872	118.995	10.91	17.4
	Y	23	518	22.522	61102	2183.877	46.73	74.7
	Z	23	16713	726.652	12267291	5529.951	74.36	118.9
10,000 ft Passes 3 and 4 Combined	X	27	1207	44.704	22315	122.091	11.05	17.6
	Y	27	582	21.556	20951	123.116	11.10	17.8
	Z	27	15116	559.852	851050	2269.280	47.64	76.2

was flown approximately 1000 ft behind at the same altitude. All three aircraft carried MATTS frequency sources. When the rear aircraft (simulating the rocket) initiated a manual burst signal, a Hatcher (Model 102) camera carried on the midwing pylon of the right wing photographed the two lead aircraft (simulating the interceptor and target). Stadiometric measurements were used to analyze the film data to obtain the distances between the rear aircraft and the two lead aircraft. The distances obtained from the film were compared with the real-time printouts of the MATTS. After careful analysis, this method of measuring the MATTS scoring accuracy was proven inaccurate. The differences that were apparent between the film and the MATTS were so great that this method of measurement was condemned. Another yardstick had to be devised.

As an alternate method of obtaining scoring accuracy information, the two lead T-33 aircraft previously flown were utilized, and a B-57 with two Mod IV cameras in a pod on each wing was substituted for the rear T-33. The B-57 was flown approximately 500-800 ft behind the two lead aircraft (Fig. 20). This modified formation was flown over the areas indicated in Fig. 21. The space positions of the two lead aircraft were determined from the film data by using the Bodwell least squares method.<sup>3</sup> It was intended that the data accrued on these missions would be used for evaluation of the operation of the phase meters and the overall performance of the MATTS. Also, it was anticipated that the data accrued would readily lend themselves to extrapolation to the higher altitudes. However, it soon became evident that these data could not be thus extrapolated with any great degree of accuracy.

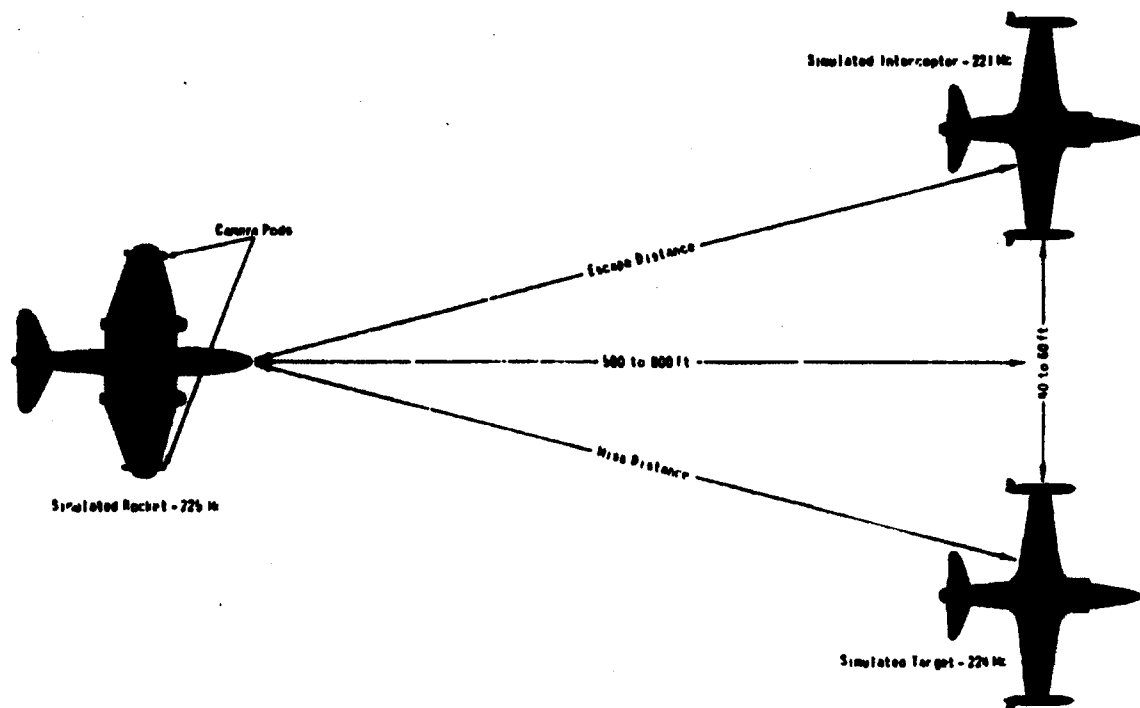


Fig. 20: Scoring Accuracy Formation Utilizing One B-57E and Two T-33 Aircraft

To investigate the higher altitudes (45,000 and 55,000 ft), the two lead T-33 aircraft were replaced by two B-57E aircraft, and this formation was flown over the flight paths denoted in Fig. 22 at altitudes of 17,500, 35,000, and 45,000 ft. Employing this airborne yardstick, measurements with  $\pm 5$  ft accuracy were obtained. However, since the aircraft could not attain altitudes higher than 45,000 ft and hold the formation required for the test, no data were obtained above this altitude. The areas represented in Fig. 22 were of primary importance due to ADC requirements for explicit data along the designated flight paths. Due to the random nature of the data obtained, the only areas that can be discussed are the areas shown in this figure, and no extrapolation to areas outside the flight paths have been presented.

**RESULTS.** The modified formations were flown over the testing area during the period from 20 Sep to 11 Oct 61. The collected data points were approximately one nautical mile apart. All the data from these missions are presented in Appendix I.

The MATTS antennas were placed on the forward section of each aircraft used in the simulation of the intercept. All MATTS measurements were made to the MATTS antennas. The film data were reduced

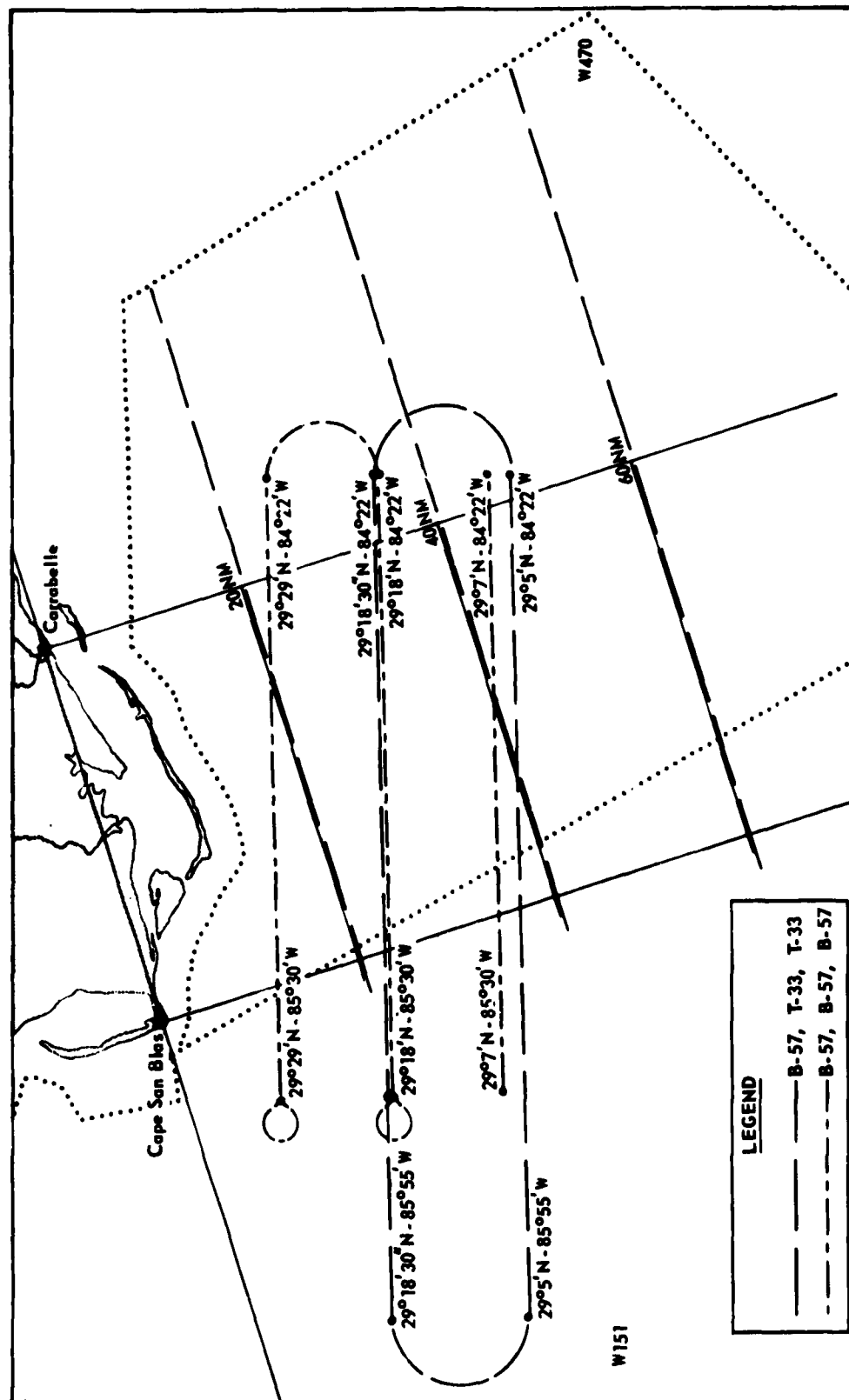


Fig. 21: Scoring Accuracy Flight Profiles

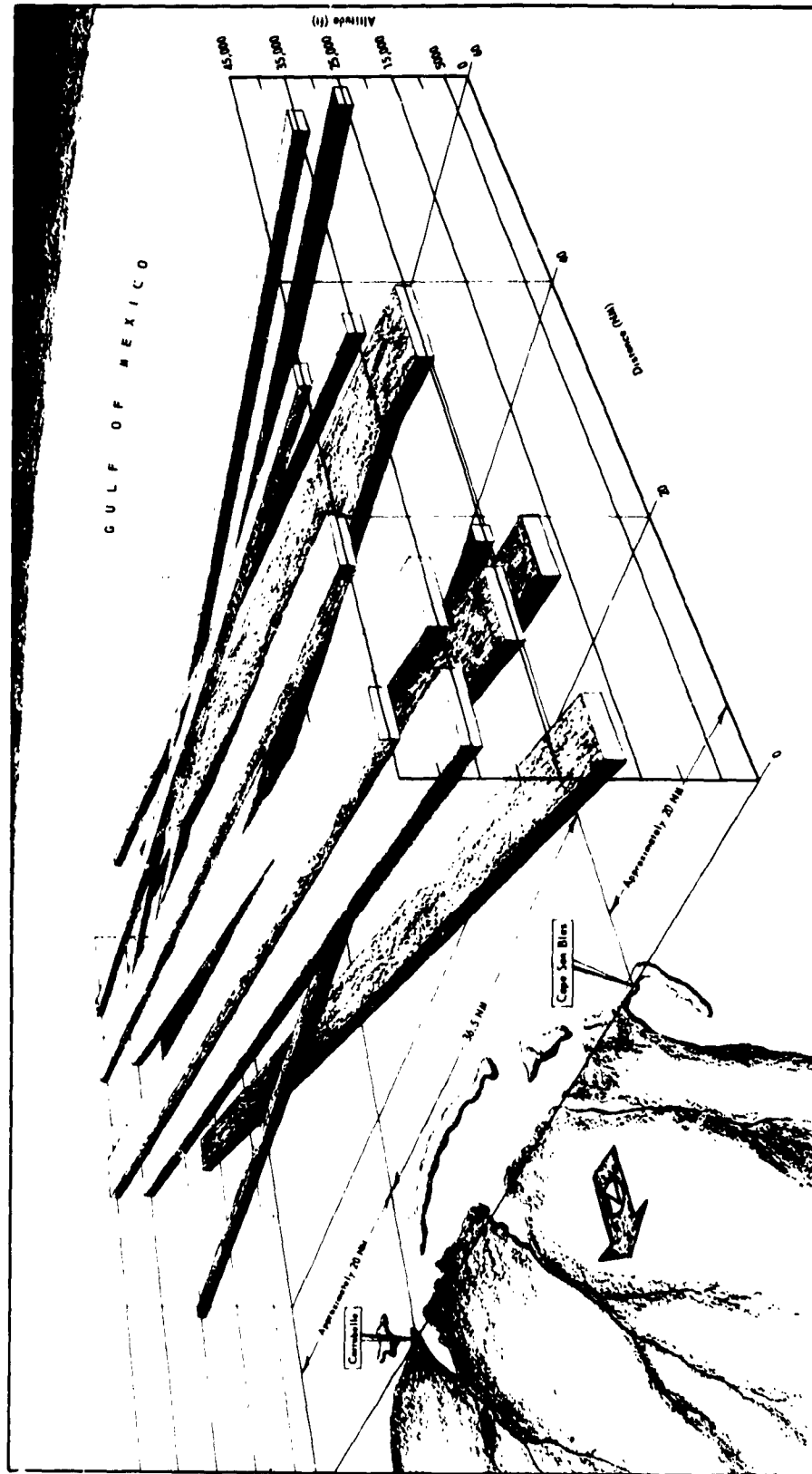


Fig. 22: Scoring Accuracy Test Envelopes

by measuring the distance from the camera pods in the rear aircraft to points of opportunity on the lead aircraft, for example, the engine, wing tip, tail, etc. To make the film measurements compatible with the MATTS measurements, then, it was necessary to correct the film data for the distance from the point of measurement to the antenna location on the aircraft.

Using the corrected camera data as the standard, the MATTS miss- and escape-distance errors were obtained. The MATTS real-time print-out was compared with the camera data. The error was positive or negative depending upon whether the distances as measured by the MATTS were greater or less, respectively, than the camera data showed.

The errors apparent in Appendix I range from 0 to well over 1000 ft. Recalling that the data points were approximately a mile apart, it is significant to mention that the difference between two consecutive real-time printouts ranges from 0 to well over 800 ft. This large difference indicates no connection or trend between separate data points.

The data accrued during the period 27 Sep to 7 Oct 1961 were obtained on flight paths parallel to the Y base line at distances of 20, 40, and 60 NM over the water range, and on one of the SAGE drone tracks. The north and south legs of the drone track, shaped like a racetrack, are defined by the coordinates:

North leg:	29° 18' 30" N - 85° 55' W
	29° 18' 30" N - 84° 22' W
South leg:	29° 5' N - 85° 55' W
	29° 5' N - 84° 22' W

During the period from 7 Oct to 11 Oct, missions were accomplished on the William Tell drone track. This track is also shaped like a racetrack, and the coordinates of the north and south legs are:

North leg:	29° 29' N - 85° 30' W
	29° 29' N - 84° 22' W
South leg:	29° 18' N - 85° 30' W
	29° 18' N - 84° 22' W

(This leg closely approximates the North leg of the SAGE drone track.)

During this last period, data were collected on another flight path at 45,000 ft altitude. This flight path is included in Fig. 22. The coordinates of the end points of the flight path are:

West end: 29° 7' N - 85° 30' W

East end: 29° 7' N - 84° 22' W

Antenna look angles were derived from these flight paths.

Looking out over the water range to each end and the midpoint of each of the flight paths, curves of elevation angle vs azimuth angle were determined for each site. The values obtained are shown in Table 7 and the curves the angles defined are shown in Figs. 23 and 24. Because of the orientation of the two sites with respect to the drone tracks, the elevation angles at the ends of the tracks opposite each of the sites decreased sharply. As can be seen from Fig. 23, the eastern end of the drone tracks yielded relatively low antenna look angles for the Cape San Blas site. The western end yielded low elevation angles for the Carrabelle site (see Fig. 24). The differences apparent in the curvature of the elevation angle plots for each site are dependent upon their respective orientations to the flight paths. San Blas elevation angles remain relatively constant over the western and middle sections of the flight paths, then decrease sharply at the eastern extremity. Carrabelle elevation angles remain relatively constant until, at the western end, they decrease sharply.

Theoretically the data collected from airborne events where the elevation angles from each site were equal should have been most accurate. This situation was investigated on all the flight paths where scoring data were collected using the three B-57 aircraft formation. It was anticipated that as the elevation angle increased, the errors of the scoring measurements would decrease. Logically, the point on each of the flight paths that yielded equal elevation angles from each site (also the same distance) lay on a line projected out over the water range equidistance from each site. Thus, for each altitude and flight path involved, there existed a single equal elevation angle for each site. To obtain an area encompassing a group of data points, the elevation angle was expanded  $\pm 10\%$  of its magnitude. This band of values was small enough to allow the assumption that the elevation angle remained relatively constant everywhere within the  $\pm$  limits.

The defined flight paths of the William Tell drone track and extra leg and calculated errors are presented in Figs. 25, 26, 27, and 28. The elevation angles used to define the areas on these flight paths are shown in Table 8. The data included within the areas at each altitude were averaged (exclusive of algebraic sign), and these values are also presented in Table 8. As can be seen from the table, with the exception of the data at 25,000 ft on the south leg, the calculated data do indicate a trend of improvement with an increase of elevation angle. Although

TABLE 7. AME LOOK ANGLES FOR SCORING ACCURACY PROFILE

Altitude (ft)	North Leg William Tell Drone Track				South Leg William Tell Drone Track						Extra Leg at 45,000 ft Only		
Cape San Blas													
	Azimuth Angles (deg)												
	-53	10	47	60	-38	0	32	41	46	48	-32	24	40
	Elevation Angles (deg)												
17,500	10.8	12.2	6.1	3.1	6.8	6.85	4.86	3.9	3.3	2.98	-	-	-
25,000	-	-	-	-	9.5	9.7	6.9	5.5	4.7	4.3	-	-	-
35,000	21.0	23.5	12.0	6.3	13.5	13.5	9.6	7.64	6.58	6.0	-	-	-
45,000	26.4	29.1	15.4	8.0	16.8	17.1	12.2	9.8	8.4	7.8	11.9	9.4	6.9
Carrabelle													
	Azimuth Angles (deg)												
	-80	-28	18	-	-70	-57	-48	-32	0	8	-62	-25	3
	Elevation Angles (deg)												
17,500	3.3	6.5	5.9	-	3.0	3.83	4.2	4.7	4.7	4.53	-	-	-
25,000	-	-	-	-	4.3	5.5	6.0	6.7	6.7	6.5	-	-	-
35,000	6.7	13.0	11.8	-	6.0	7.64	8.4	9.34	9.34	9.0	-	-	-
45,000	8.6	16.5	15.0	-	7.8	9.8	10.7	12.0	12.0	11.5	6.8	9.4	8.9

the data sample within the defined areas at each altitude was assumed to be the best, it was also very limited. The tracking error established for the extreme western areas of the SAGE drone track was too large for use in a scoring accuracy evaluation. The south leg of the SAGE drone track and the 60 NM flight path at and below 40,000 ft yielded errors in miss and escape distances that exceeded the specified limits of the MATTS. The formation (B-57, T-33, T-33) flown on the SAGE drone track and the 60 NM leg is suspected of being somewhat lacking in effectiveness. This is verified by the deviation of the average absolute magnitude of the errors encountered at 25,000 ft from the trend established by the data from the other altitudes (Table 8). The above mentioned formation was flown on the 80 NM leg parallel to the Y base line, involving elevation angles of  $2\frac{1}{2}^{\circ}$  to  $3^{\circ}$ . The tracking data collected on this flight path at 25,000 ft were so erratic that no scoring accuracy evaluation could be accomplished. Data obtained on the 20 and 40 NM flight paths were incorporated in the data for the north and south legs, respectively, of the William Tell drone track.

The errors of the miss and escape measurements at each altitude were of such random nature that no geographical scoring accuracy volume could be defined. Therefore, the data were separated as to altitude

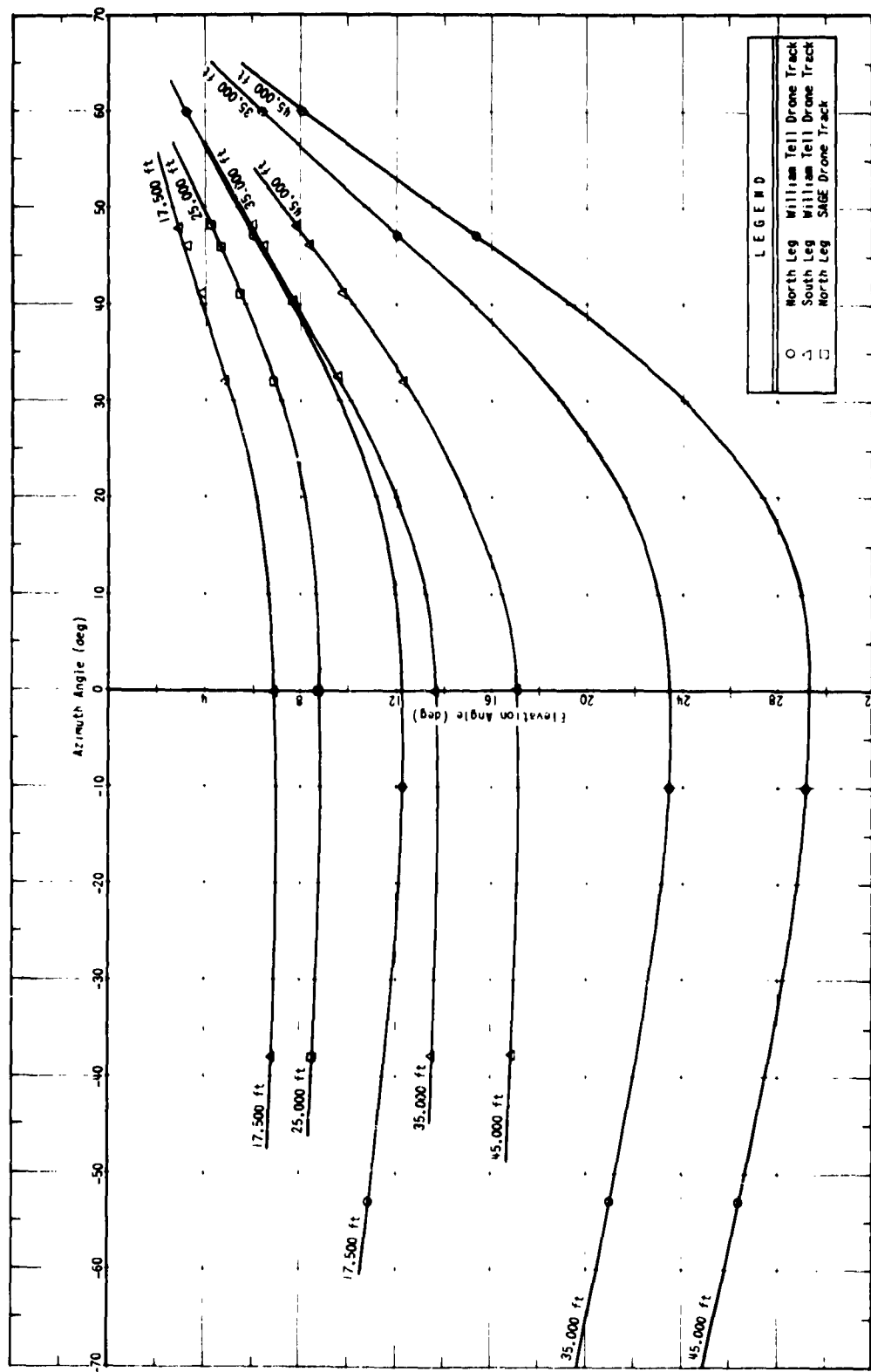


Fig. 23: Cape San Blas Look Angles for Scoring Accuracy Flight Paths

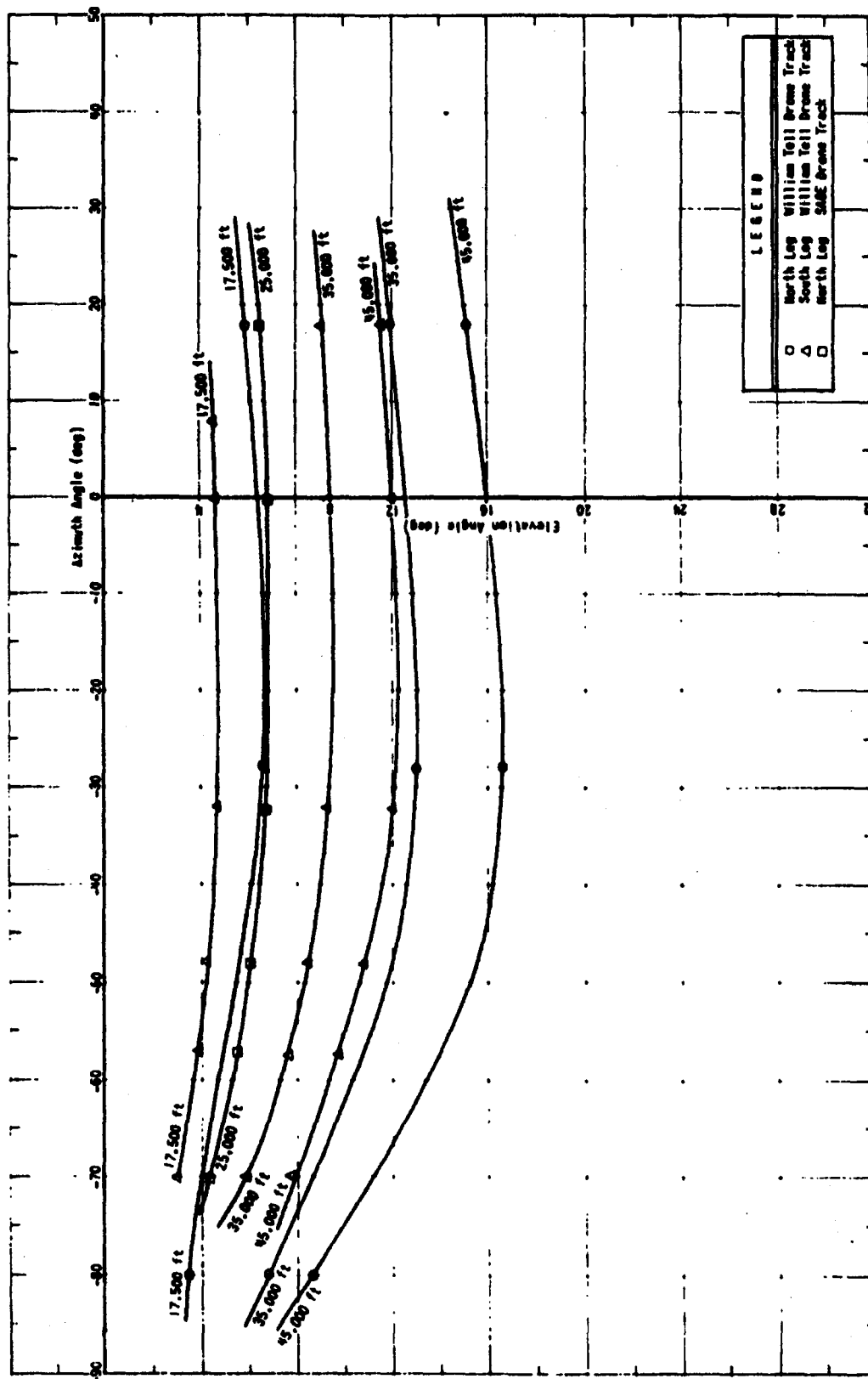


Fig. 24: Carrabelle Look Angles for Scoring Accuracy Flight Paths

TABLE 8. SCORING ACCURACY VERSUS ELEVATION ANGLE

Altitude of Flight Path (ft)	No. of Samples in Area	Elevation Angle of Flight Path (deg)	Average Absolute Magnitude	
			Miss Errors (ft)	Escape Errors (ft)
North Leg of the William Tell Drone Track				
17,500	4	6.6	55.0	73.0
35,000	7	12.9	60.6	64.8
45,000	6	16.2	50.0	20.5
South Leg of the William Tell Drone Track				
17,500	7	5.0	51.0	60.0
25,000	6	6.9	164.0	140.0
35,000	10	9.6	60.8	30.6
45,000	4	12.3	37.5	23.8
Extra Leg South of William Tell Track				
45,000	5	9.52	99.8	69.6

and flight path and enclosed in rectangles about the flight paths. The corners of the rectangle are defined by the coordinates presented in Table 9.

For each region so defined, the mean, standard deviation, and 90% confidence limits for the miss and escape distance errors were determined, also the maximum and minimum values encountered for these errors.

The values given in Tables 7, 8, and 9, which comprise the results of the test, are seen to have considerable random variation. In fact, aside from the increase in error as the elevation angle decreases, which results in excessive errors at angles below 4°, no definite trends were noted, nor were any sharp limits found separating the regions of acceptable performance from those of unacceptable performance.

The overall system was investigated during this test, and within the areas defined by Table 9, the system is within design specifications. However, as has been previously stated, there were certain areas not investigated and others that produced data too poor to be assessed.

DATA FOR FIG. 25

Mission No. - Data Point No.	Measurement Error (ft)		Mission No. - Data Point No.	Measurement Error (ft)	
	Miss	Escape		Miss	Escape
North Leg - 17,500 ft Altitude			South Leg - 17,500 ft Altitude		
51-29	-70	-115	51-2	69	213
451-28	131	48	51-3	-4	241
51-32	61	29	451-4	483	30
51-28	71	333	51-56	33	154
451-27	20	-34	451-5	52	35
51-33	31	142	51-4	-2	25
51-27	45	26	51-55	-41	97
451-33	20	175	451-6	-22	14
51-26	-66	16	51-5	-23	48
51-34	53	50	51-54	-6	1
451-26	-5	-54	51-6	-212	-74
451-34	24	36	451-8	-35	7
51-25	-66	-130	51-53	-19	151
51-35	0	46	51-7	16	-31
451-25	-17	34	451-9	2	34
51-24	-26	-89	51-52	-75	134
51-36	-49	23	451-10	-3	-41
451-24	61	-35	51-8	42	-66
51-23	-110	-131	51-51	-137	-22
51-37	-20	121	451-11	13	48
451-23	15	-32	51-9	136	-18
51-38	-52	35	51-50	-62	105
51-22	-171	-152	51-10	-87	-55
451-22	55	1	451-12	164	466
51-21	-153	-129	51-49	225	615
51-39	2	-4	51-11	-91	247
51-20	-162	2	51-48	-21	156
451-20	64	53	451-13	101	-10
51-40	105	159	51-12	-36	74
51-19	-110	-73	51-47	20	170
51-41	2	50	451-14	26	Ambiguity
451-19	-38	89	51-46	628	430
51-18	287	-81	451-15	1699	2372
51-42	31	478			
451-18	247	214			
51-17	-129	131			
51-43	74	205			
451-17	130	915			
51-16	-79	46			
51-44	235	574			

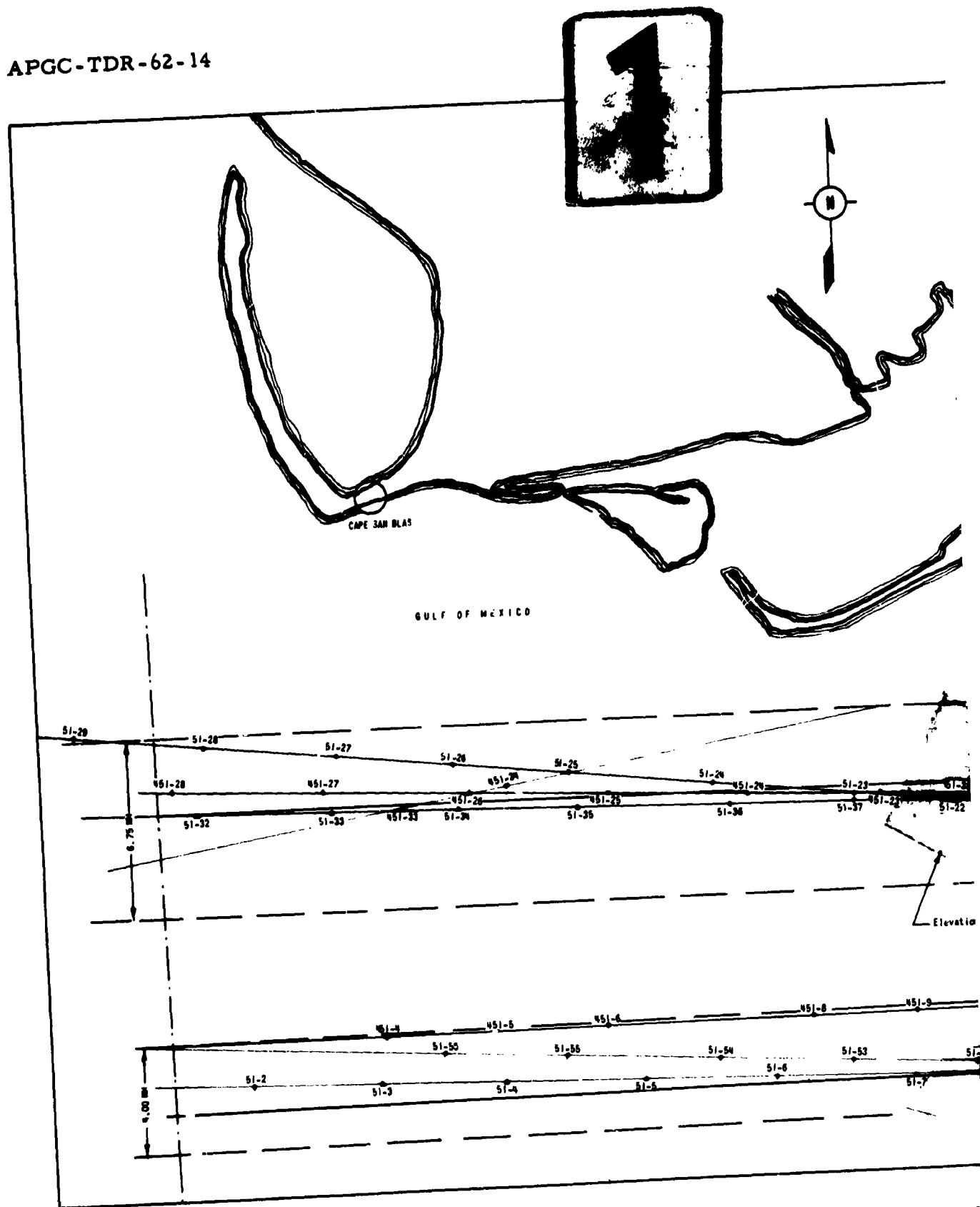
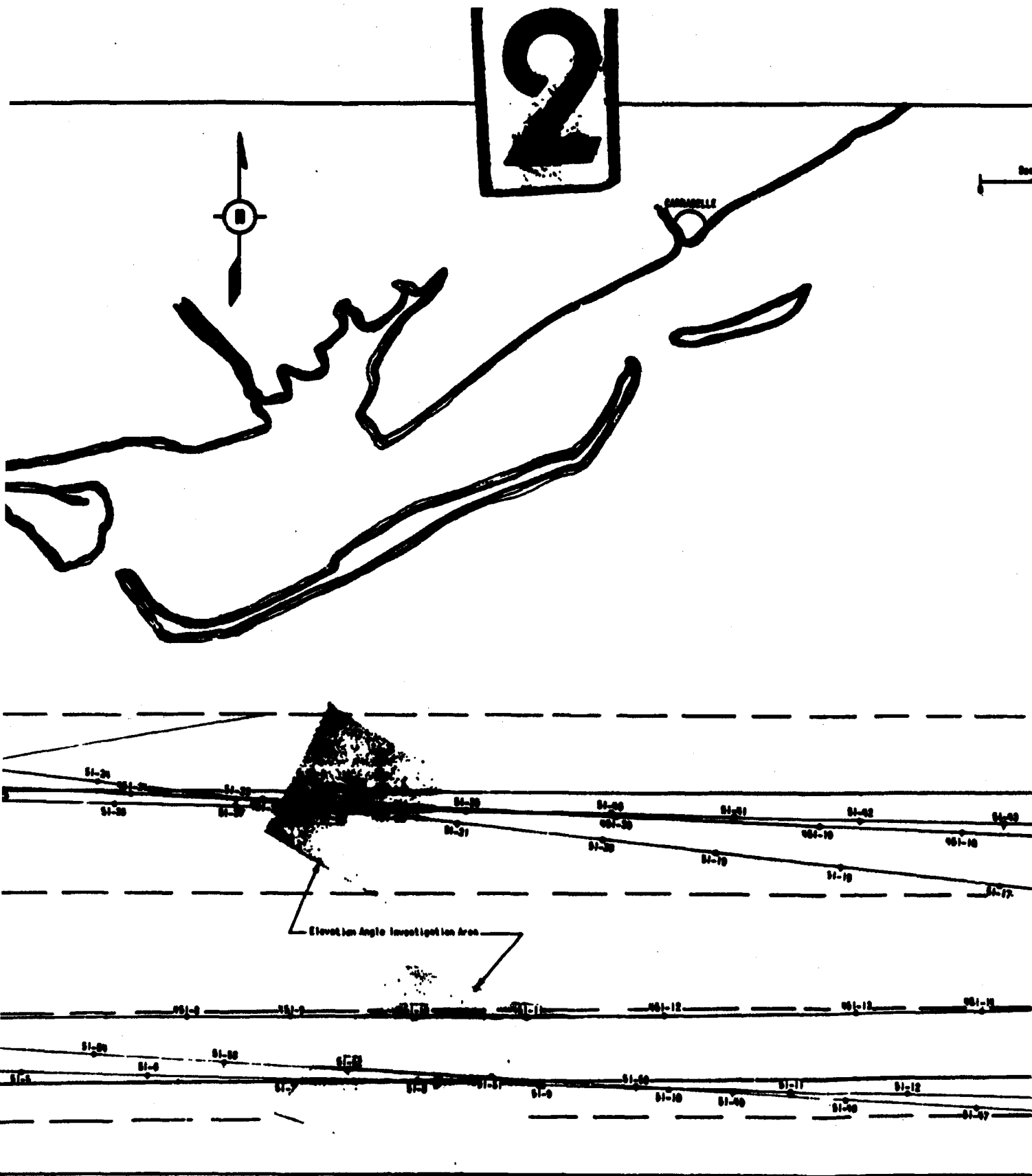
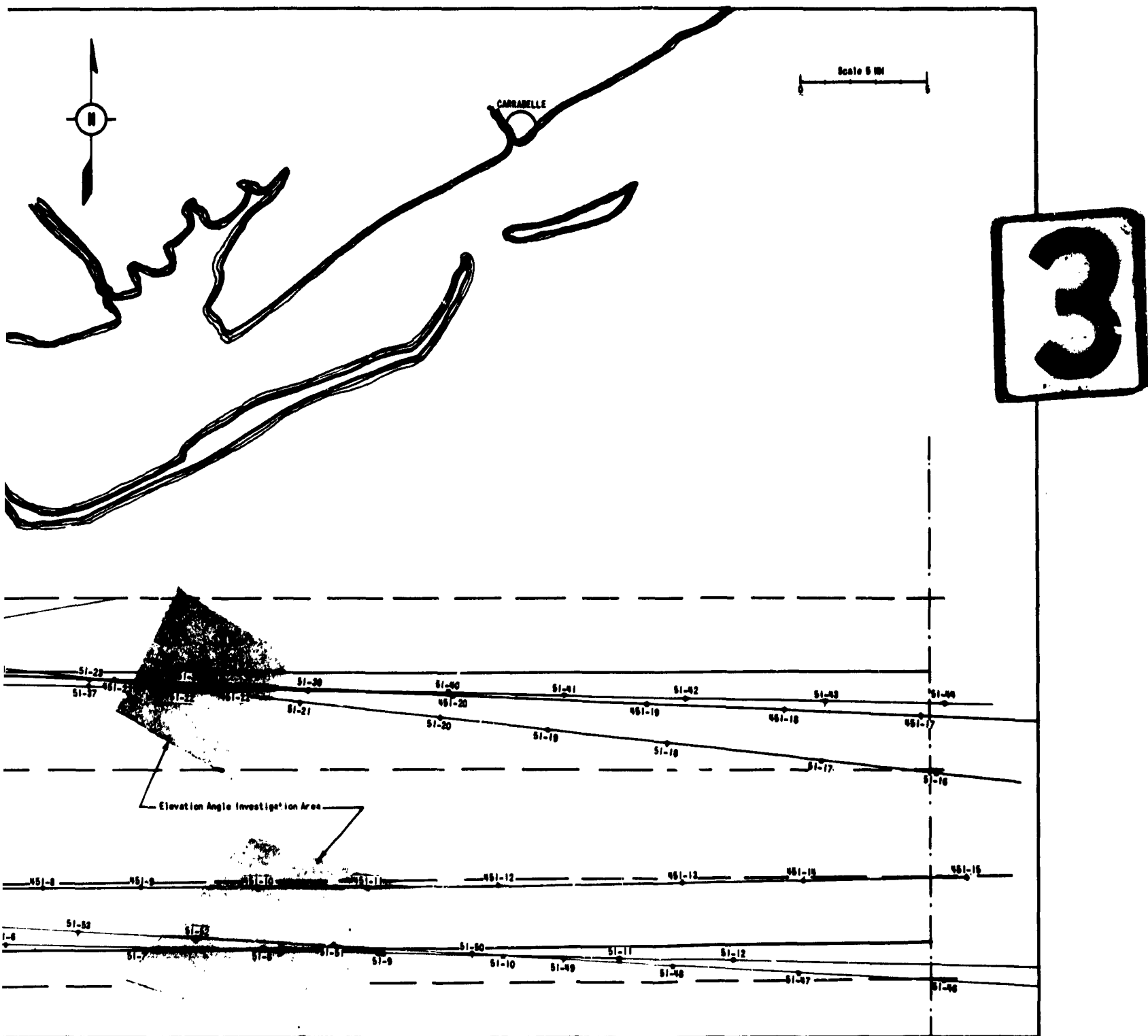


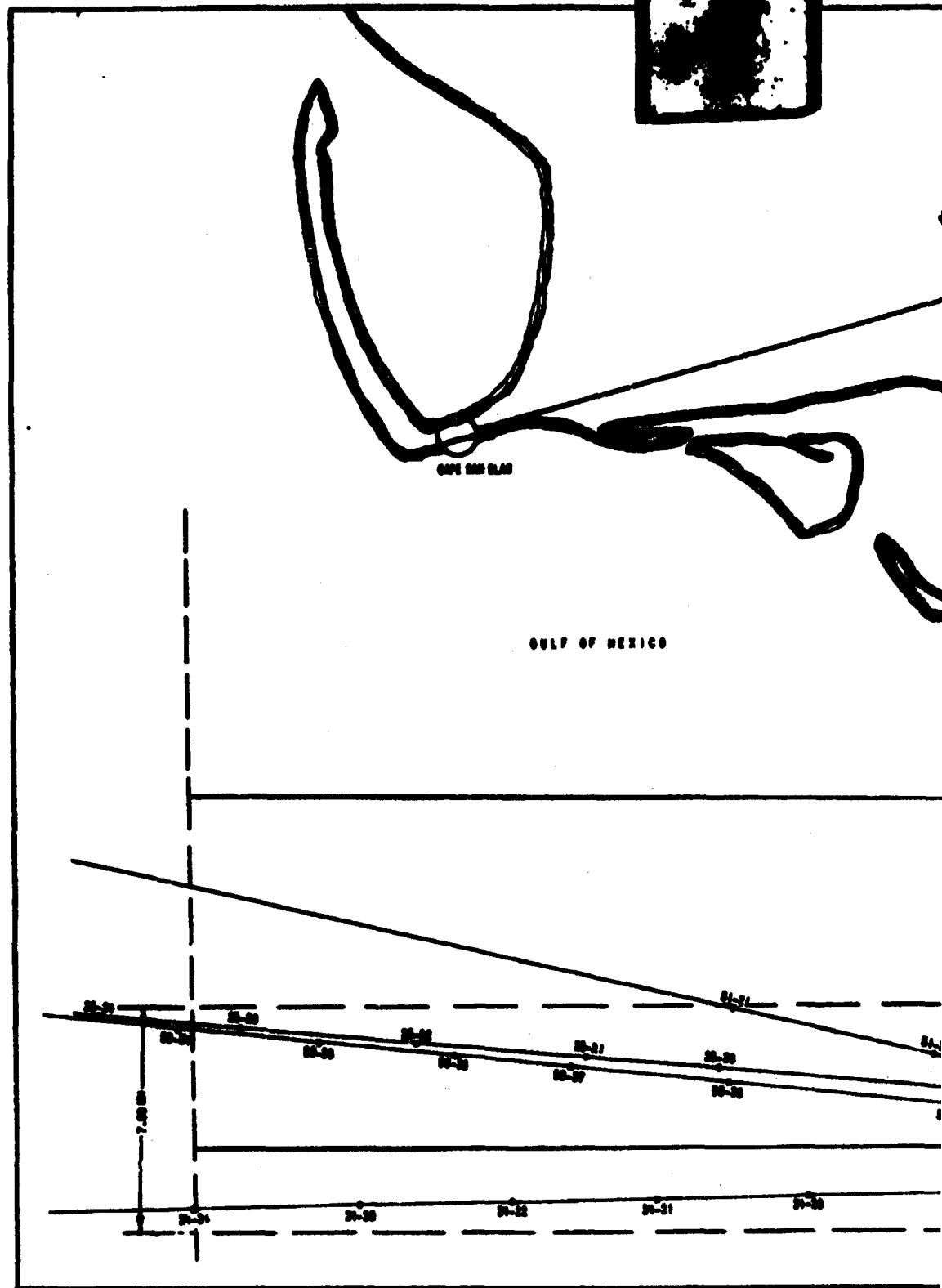
Fig. 25: William Tell Drone Track



25: William Tell Drone Track and Associated Data at 17,500 ft



Tell Drone Track and Associated Data at 17,500 ft



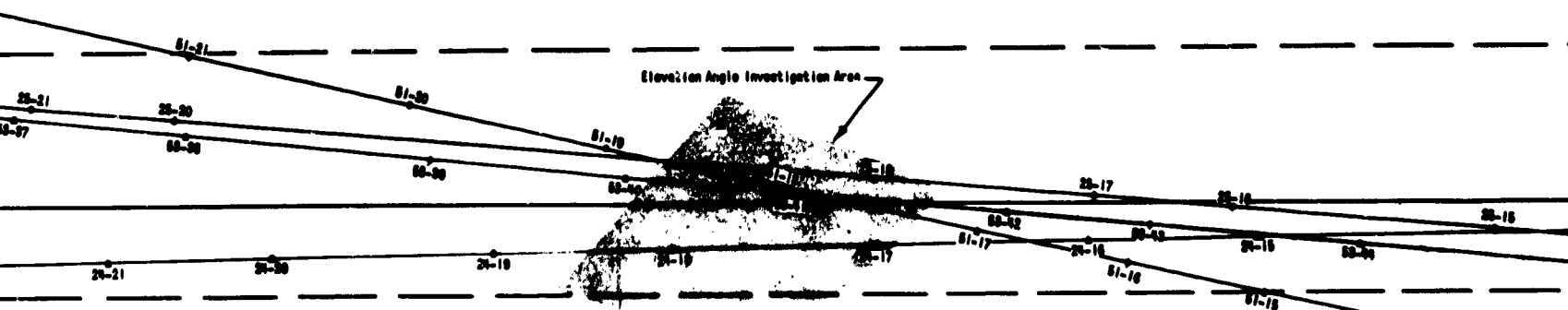
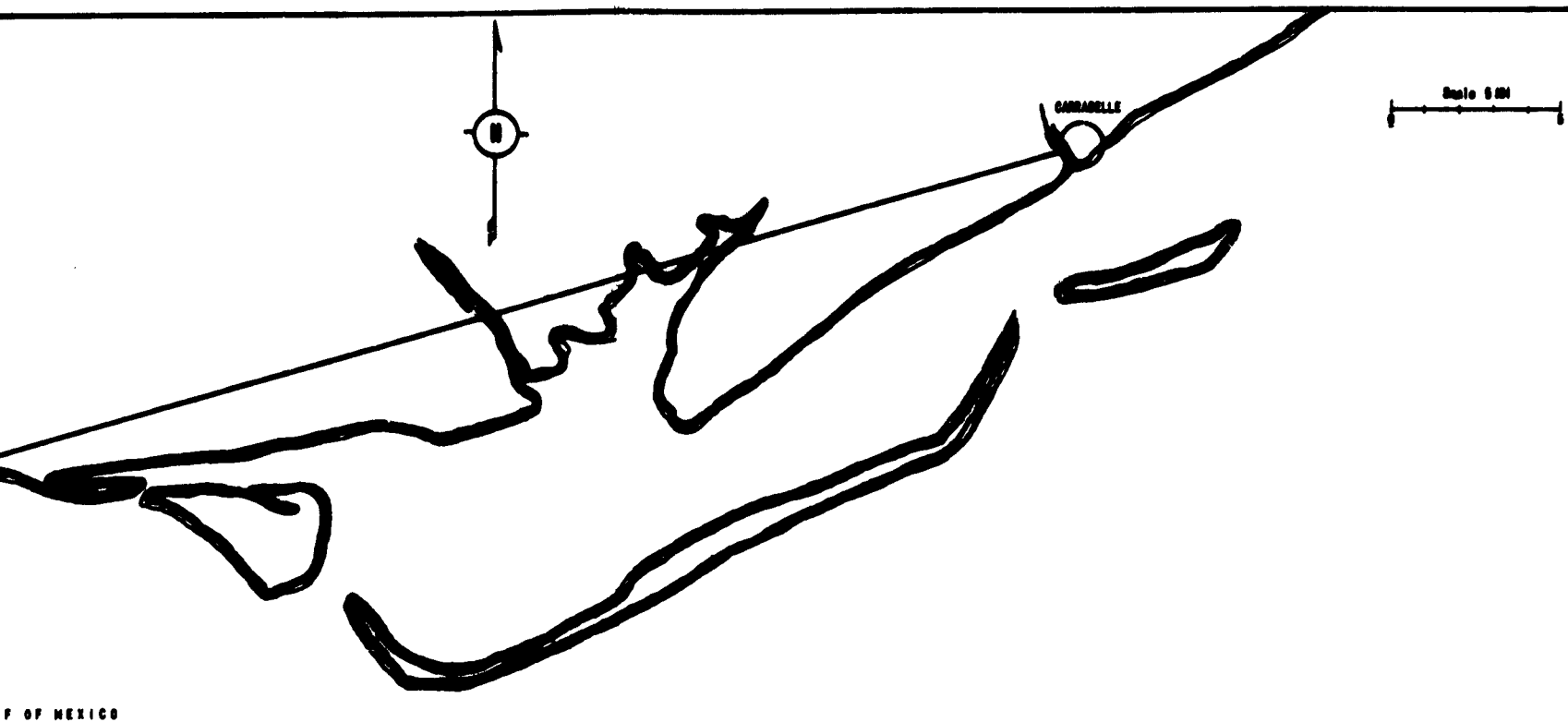
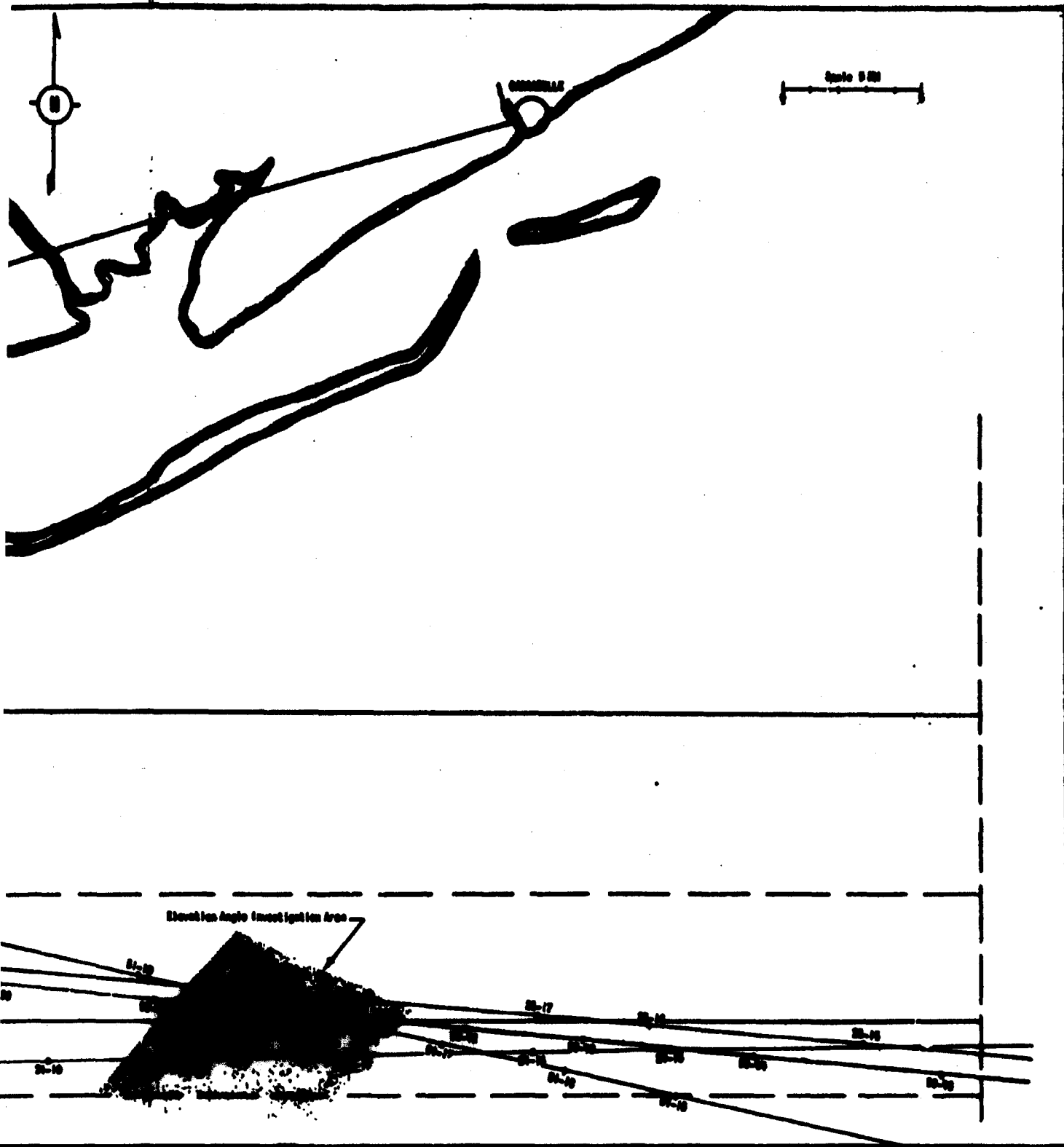


Fig. 26: William Tell Drone Track and Associated Data at 25,000 ft





rone Track and Associated Data at 25,000 ft

DATA FOR FIG. 26

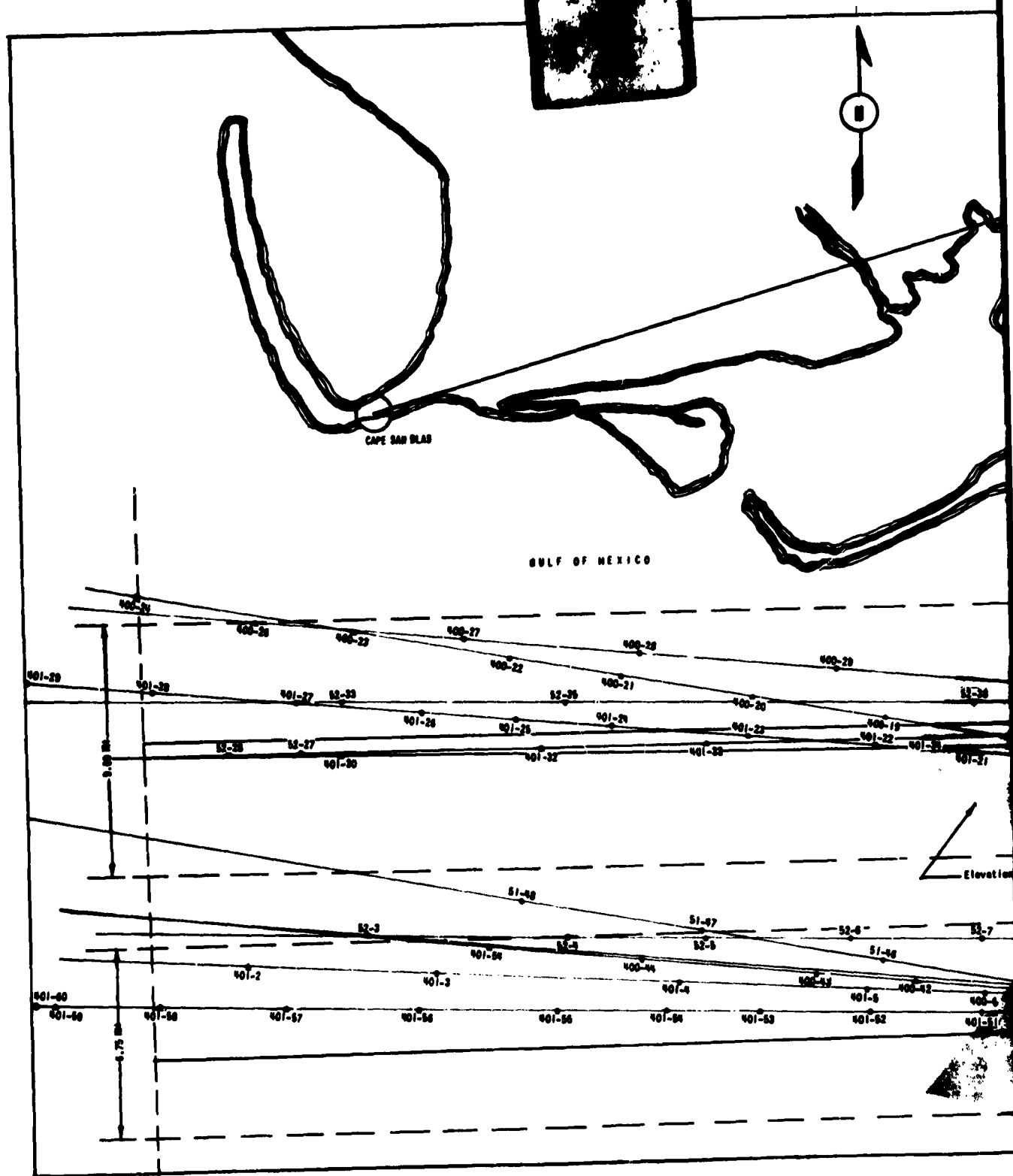
Mission No. - Data Point No.	Measurement Error (ft)	
	Miss	Escape
South Leg - 25,000 ft Altitude		
25-24	91	215
53-34	90	128
24-24	-13	-4
25-23	24	-38
53-35	171	485
24-23	31	601
25-22	91	184
53-36	118	208
24-22	33	122
53-37	112	154
25-21	176	144
24-21	40	113
25-20	22	118
51-21	185	192
53-38	75	-30
51-20	175	295
53-39	177	436
24-19	19	253
51-19	83	166
53-40	200	146

Mission No. - Data Point No.	Measurement Error (ft)	
	Miss	Escape
South Leg - (Continued)		
24-18	51	143
51-18	110	252
53-41	129	146
25-18	111	103
24-17	243	193
51-17	142	124
53-42	105	168
25-17	277	162
24-16	108	109
51-16	339	188
63-43	150	180
25-16	142	234
24-15	71	206
51-15	155	250
53-44	-26	1
25-15	Ambiguity	Ambiguity
53-45	411	281

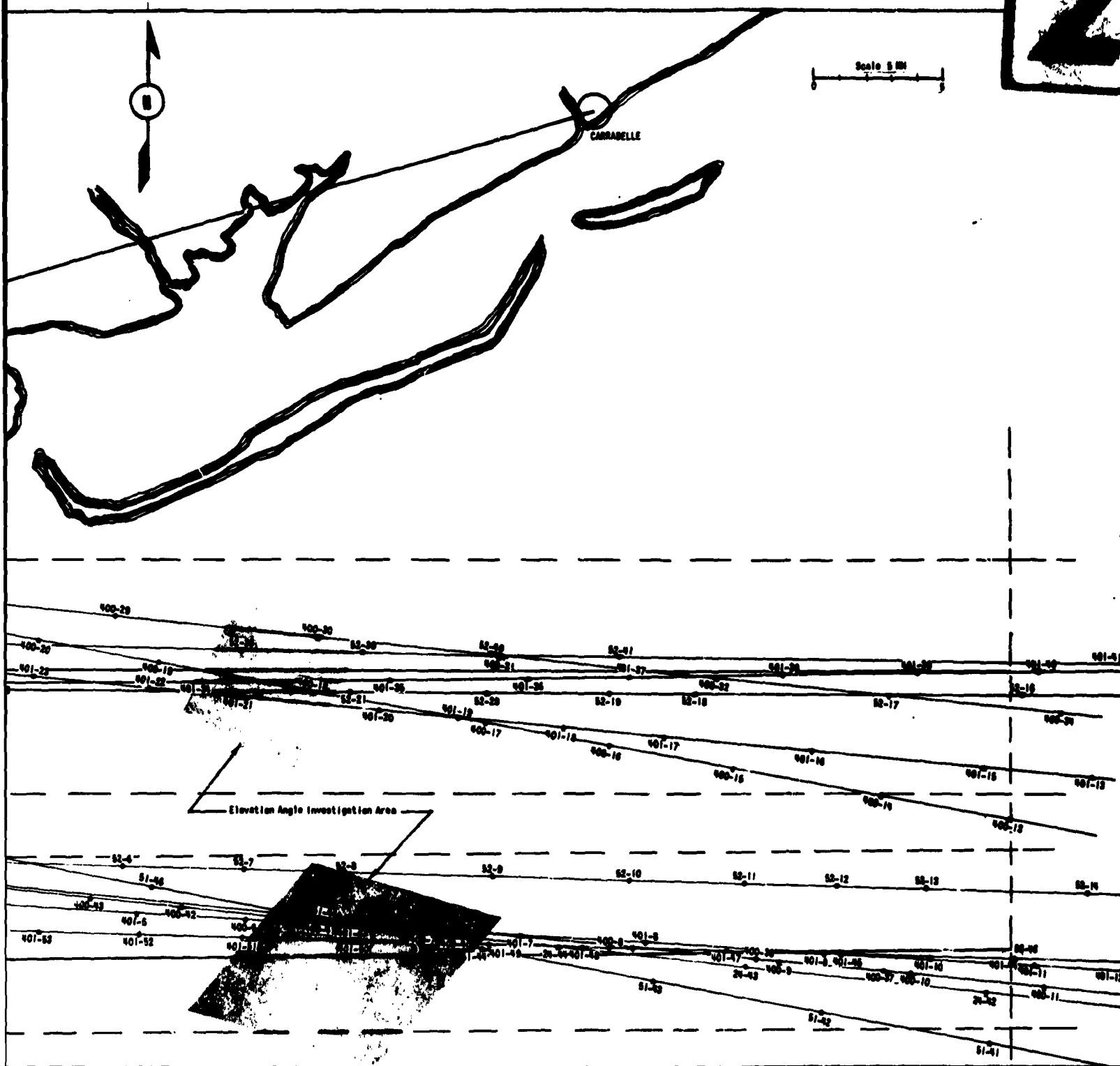
## DATA FOR FIG. 27

Mission No. - Data Point No.	Measurement Error (ft)	
	Miss	Escape
North Leg - 35,000 ft Altitude		
401-29	23	16
401-24	-	-
401-28	-4	-14
52-28	51	-6
400-26	42	126
401-27	8	11
401-30	-153	-20
400-23	1	26
52-33	20	-17
52-27	-7	110
401-26	-8	20
400-27	62	82
400-22	56	95
401-25	-1	55
401-32	46	128
52-39	57	14
401-24	15	47
400-21	21	60
400-28	84	130
401-33	42	103
401-23	-2	50
400-20	87	140
400-29	136	163
400-19	105	128
401-22	25	45
401-34	-46	19
52-38	47	-14
401-21	29	61
400-30	205	156
400-18	82	127
52-21	14	-42
52-39	31	-5
401-20	7	33
401-35	0	49
400-17	64	107
52-40	36	-33
52-20	0	35
401-19	12	30
400-31	137	187
401-36	20	-19
401-18	31	40
52-19	-18	73
400-16	92	112
52-41	49	-18
401-37	9	6
401-17	-43	8
52-18	-29	-6
400-32	61	68
400-15	48	111
401-38	38	56
401-16	-58	7
400-14	71	176
52-17	64	-11
401-39	6	40
401-15	54	6
400-13	154	65
52-16	39	51
401-40	34	69
400-34	96	173
401-13	-72	240
401-41	156	117
-	-	-
-	-	-

Mission No. - Data Point No.	Measurement Error (ft)	
	Miss	Escape
South Leg - 35,000 ft Altitude		
401-60	16	44
401-59	-17	126
401-58	-45	179
401-2	90	116
401-57	-74	-53
52-3	-1	15
401-56	-28	67
400-45	2	64
51-48	81	93
401-55	-51	19
52-4	-30	-8
400-44	-47	-45
401-54	16	73
401-4	15	63
51-47	110	209
52-5	2	27
401-53	-48	93
400-43	-11	-12
52-6	40	29
401-5	49	45
401-52	-19	68
51-46	20	128
400-42	13	33
401-51	-34	40
52-7	11	33
400-6	91	89
51-45	25	118
400-41	16	61
52-8	23	5
401-6	16	29
401-50	-2	94
400-7	116	137
400-40	-6	36
51-44	56	96
401-49	-12	32
52-9	36	45
401-7	-8	27
24-44	-14	94
401-48	43	24
400-8	94	184
52-10	3	21
400-39	10	36
401-8	15	71
51-43	66	134
401-47	-10	12
24-43	61	132
52-11	-104	-5
400-38	18	-18
400-9	106	208
401-9	8	64
52-12	-24	13
51-42	173	161
400-10	29	67
52-13	-51	17
401-10	14	30
401-45	46	58
24-42	260	239
51-41	69	141
400-37	156	125
401-44	326	298
52-46	71	219
401-11	3	26
400-11	288	196
101-12	97	73
52-14	173	-47



**Fig. 27: William Tell Drone Track a**



### **Liam Tell Drone Track and Associated Data at 35,000 ft**

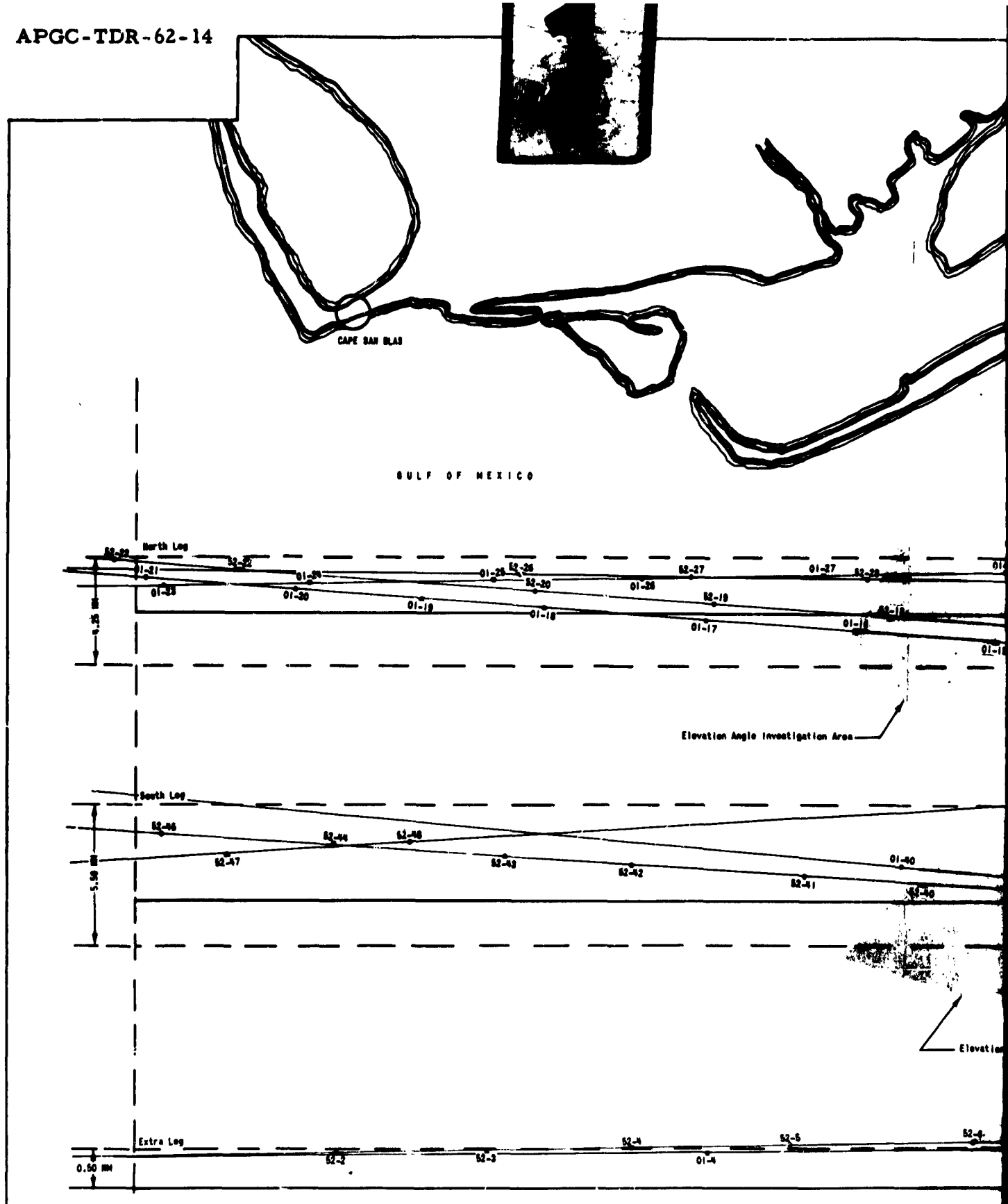
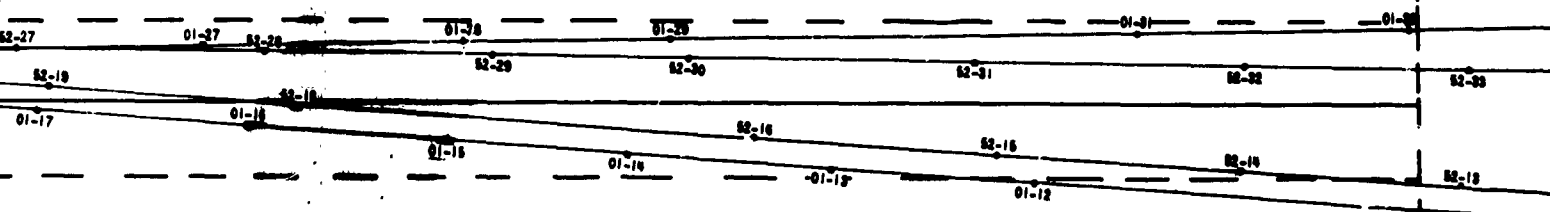
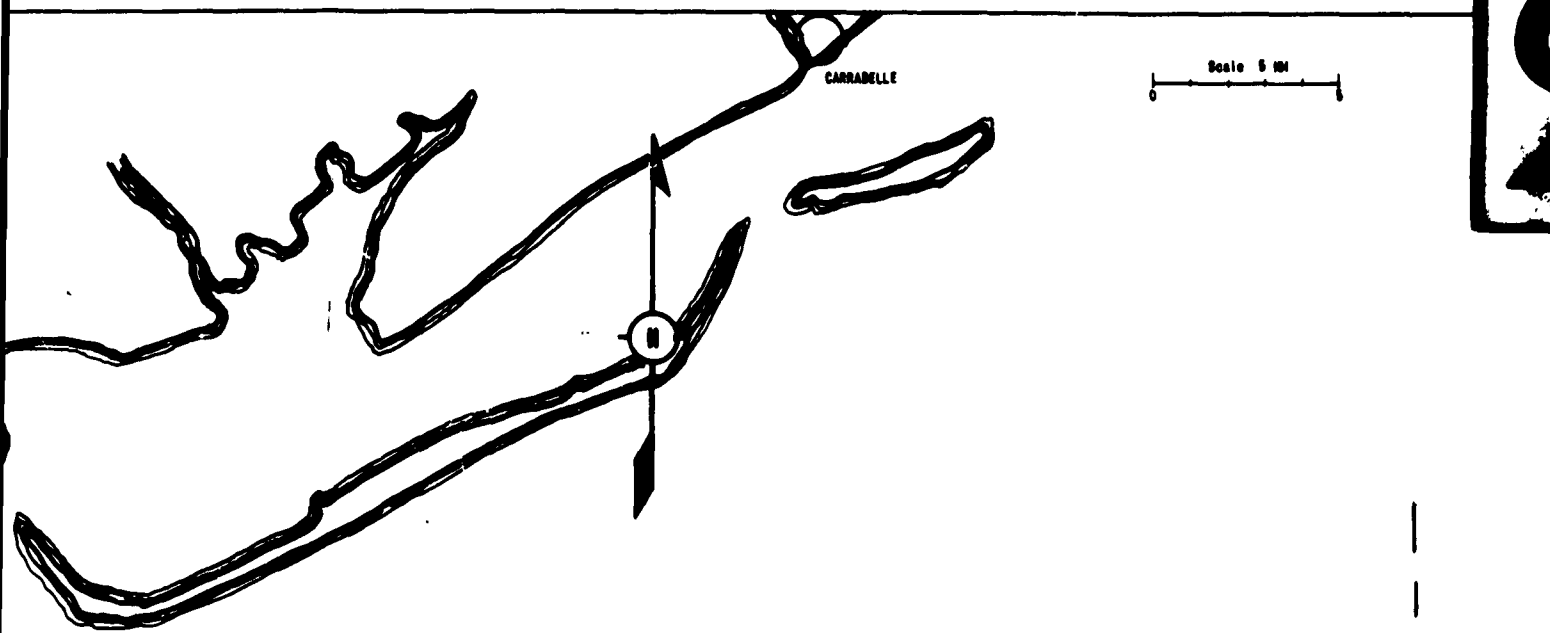


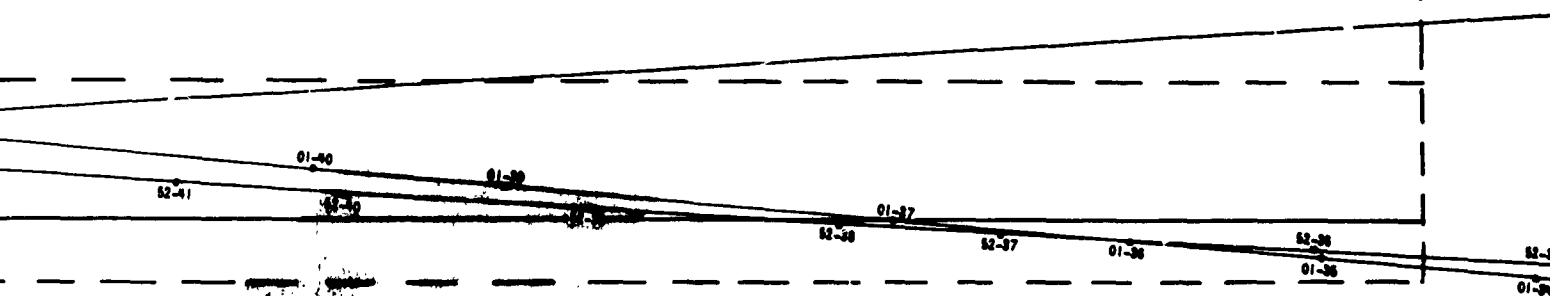
Fig. 28: William Tell Drone Track and Associated Data at 45,000 ft

CARRABELLE

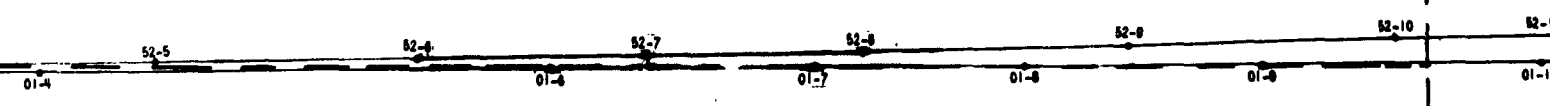
Scale 5 NM



Elevation Angle Investigation Area



Elevation Angle Investigation Area



5,000 ft

## DATA FOR FIG. 28

Mission No. - Data Point No.	Measurement Error (ft)		Mission No. - Data Point No.	Measurement Error (ft)		Mission No. - Data Point No.	Measurement Error (ft)	
	Miss	Escape		Miss	Escape		Miss	Escape
North Leg - 45,000 ft Altitude			South Leg - 15,000 ft Altitude			Extra Leg - 45,000 ft Altitude		
52-23	-68	-81	52-45	-4	26	52-2	13	8
01-21	-30	27	52-47	-22	70	52-3	115	116
01-23	1	66	52-44	-24	0	52-4	-54	21
52-22	-17	8	52-48	14	46	01-4	2	43
01-20	-21	32	52-43	14	17	52-5	-5	51
01-24	66	166	52-42	-41	52	52-6	576	372
01-19	-30	44	52-41	35	63	01-6	-17	66
01-25	8	96	01-40	-1	66	52-7	-15	20
52-26	6	40	52-40	50	19	01-7	-20	68
52-20	-44	-11	01-39	6	58	52-8	281	301
01-18	-21	9	52-39	-38	0	01-8	-14	12
01-26	0	-20	52-38	-28	-77	52-9	-18	28
52-27	-1	11	01-37	-1	76	01-9	-27	-19
01-17	-35	76	52-37	28	16	52-10	116	300
52-19	40	103	01-36	-59	72	01-10	-9	70
01-27	-38	115	52-36	-34	58	52-11	-61	44
01-16	18	90	01-35	8	119			
52-28	-22	-2	01-34	125	161			
52-18	-24	58	52-35	1	35			
01-15	2	30						
01-28	-51	84						
52-29	6	36						
01-14	-25	18						
01-29	4	6						
52-30	3	74						
52-16	10	105						
01-13	-28	33						
52-31	50	24						
52-15	53	-42						
01-12	-109	85						
01-31	-12	78						
52-32	14	19						
52-14	-69	51						
01-32	-27	60						
52-13	-19	187						
52-33	21	5						

TABLE 9. SCORING ERROR ANALYSIS

Altitude (ft) Flight Path	Coordinates for Accuracy Rectangles				Miss Errors (ft)				Escape Errors (ft)								
	West End Constant 34° 30' W		East End Constant 84° 22' W		Standard Deviation	Maximum Value	Minimum Value	Number of Samples	40% Confidence Limits		Mean	Standard Deviation	Maximum Value	Minimum Value	Number of Samples	40% Confidence Limits	
									Upper	Lower						Upper	Lower
17,500 North Leg	28° 31' 45" N		28° 31' 45" N		11.0	103.8	-17.1	40	36.5	-16.5	74.3	223.4	-152	40	-28.4	19.6	
	28° 29' N		28° 29' N														
	28° 25' N		28° 25' N														
17,500 South Leg	28° 20' 30" N		28° 20' 30" N		35.4	150.7	-21.2	32	30.2	-16.0	102.5	155.2	-74	32	145	61.1	
	28° 15' N		28° 15' N														
	28° 10' 30" N		28° 10' 30" N														
15,000 South Leg	28° 10' 30" N		28° 10' 30" N		22	42.8	-26	37	147.5	-25.5	185	126	-38	37	200	150	
	28° 15' N		28° 15' N														
	28° 10' 30" N		28° 10' 30" N														
35,000 North Leg	28° 33' 15" N		28° 33' 15" N		35.5	57.7	-25.3	60	47.9	23.0	45.5	87	-110	60	70.3	41.3	
	28° 24' N		28° 24' N														
	28° 24' 15" N		28° 24' 15" N														
35,000 South Leg	28° 22' N		28° 22' N		36.0	74.3	-104	65	52.4	19.6	73.0	72.5	-53	65	56.1	57.9	
	28° 15' N		28° 15' N														
	28° 15' 15" N		28° 15' 15" N														
45,000 North Leg	28° 31' N		28° 31' N														
	28° 24' N		28° 24' N		-15.8	34	-106	36	-6.5	-25.6	46.1	54	-61	36	61.2	50.6	
	28° 21' N		28° 21' N														
45,000 South Leg	28° 21' 45" N		28° 21' 45" N		-37	41	-64	10	-20.7	-53.4	41.0	50	-77	10	24.2	-4.9	
	28° 18' N		28° 18' N														
	28° 16' 15" N		28° 16' 15" N														
45,000 35 NM Extra Leg	28° 8' N		28° 8' N		56	164	-61	16	127.6	15.6	93	122	-44	16	146.3	39.7	
	28° 10' 30" N		28° 10' 30" N														

SMOOTHING ROUTINE APPLICATION. Smoothed MATTS data were also compared with the camera data. Raw MATTS data were smoothed by processing it through a computer program. The program surveys 36 data points just prior to burst. If there exists a total of less than 9 erroneous data points within the 36, the program eliminates them from the computation of the miss and escape distances. However, if there are more than 9 erroneous points within the 36, the computer program throws out the data sample entirely. This is done so that a certain amount of reliability can be established for each data sample by eliminating bad data points from the computation of the miss and escape distances.

A comparison of the errors as computed using the real-time print-outs with those using the smoothed data indicated that the smoothing routine was not enhancing the MATTS results but was degrading them. Out of a total of 899 usable burst samples accrued, the smoothing routine improved or confirmed 286 (31.8%), degraded 316 (35.2%), and yielded no answer for 297 (33.0%). Eliminating the times that the smoothing routine gave no answers by not working or by rejecting the data samples, 602 useful burst samples remain. Of these 602, the smoothing routine improved or confirmed 286 (47.5%) and degraded 316 (52.5%) burst samples.

#### VERIFICATION OF OPERATION OF THE MATTS VIA LIVE FIRINGS

To affirm the operational capability of the MATTS, actual MB-1T firings were accomplished over the testing area. It was required that the MATTS score 8 out of 10 (80%) live firings. The MATTS scored 35 out of 36 from 23 Oct through 28 Oct 1961.

Because of the differences in test methodology between this test and the previous MATTS test, it would be misleading to compare the two results.

## SECTION 4 - CONCLUSIONS

1. System acquisition time varies between 0.55 and 0.8 sec.
2. The data collected during this test indicate no frequency interference or crosstalk in the system.
3. Tracking accuracy is satisfactory or acceptable throughout the testing profile, except at the extreme western end of the SAGE drone track, where the errors are too large for MATTS applications.
4. The MATTS spatial position errors in X and Y are insignificant when treated by themselves. The error in Z is excessive. After the application of a refraction correction factor, the spatial position error of the modified MATTS is comparable to the results obtained during the previous MATTS test.
5. The scoring accuracy of the MATTS meets the required accuracies for miss and escape distance calculations respectively out to the following limits:

Altitude (ft)	Distance from Cape San Blas (NM)	Distance from Carrabelle (NM)
17,500	East 51.9	27.5
	West 15.0	49.0
25,000	East 55.3	36.9
	West 24.2	55.0
35,000	East 55.3	36.9
	West 24.2	55.0
45,000	East 60.4	47.0
	West 35.0	62.5

6. Comparison of the errors obtained from the real-time printouts with those from the smoothed data indicates that the smoothing routine used during this test degrades rather than enhances MATTS data. The routine improved or confirmed 47.5% and degraded 52.5% of the burst samples that it accepted as useful.

## SECTION 5 - RECOMMENDATIONS

1. To correct some of the factors contributing to the system tracking error, it is recommended that:

a. A study of the antenna fields be accomplished to assess their effect upon the MATTS accuracy.

b. The antenna fields be investigated for the effects of obstructions to the antenna fields of view.

c. Any flight patterns that require elevation angles of less than  $4^\circ$  be avoided.

2. To improve the accuracy of the MATTS computations it is recommended that:

a. The smoothing routine be expanded and improved so that it does not degrade the data.

b. A larger computer be integrated into the system so that smoothed real-time data may be obtained.

c. A refraction correction factor be included in the computer program.

3. Further experiments over the desired operational area should be conducted only after a complete analysis of all the data collected on the MATTS, and after as many known discrepancies as possible have been corrected. These tests should utilize live firings as a primary method of collecting data.

4. New or improved calibration techniques should be developed and implemented to enhance system operation.

## REFERENCES

1. APGC-TR-61-57, Evaluation of Initial MATTS Configuration, December 1961.
2. ASD-TDR-61-40, Handbook of Instructions for MATTS (IM64-1), Vol I - System Fundamentals and RF Equipment; Vol II - Electronic Phasemeter Equipment; Vol III - Tracking Site Data Handling Equipment; Vol IV - Computer Site Equipment; and Vol V - Airborne Signal Sources, Cubic Corporation, August 1961.
3. Bodwell, C. A., A Least Squares Solution for the Cinetheodolite Problem, MTHT-138, Naval Ordnance Test Station, Inyokern, California, 12 December 1951.

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## APPENDIX I

### SCORING ACCURACY RAW DATA AND COMPUTED ERRORS

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Data Point No.	Area & Altitude	Camera Data Corrections (ft)			Camera Data (ft)				MATS Data (ft)				Errors (ft)				Remarks		
		Tar- get	Inter- cept	Rock- et	Uncorrected		Corrected*		Real-Time		Smoothed		Real-Time		Smoothed				
					Miss	Escape	Miss	Escape	Miss	Escape	Miss	Escape	Miss	Escape	Miss	Escape			
20 Sep 61 - Mission 25 - Sortie 2 - Target T-33/216 - Interceptor T-33/342 - Rocket B-57/244																			
1		+33	+31	-18	810	770	834	783	1,822	7,307	-	-	-	+ 988	+ 6,524	-	Second sortie, bad microwave		
2					-	-	-	-	-	-	-	-	-	-	-	-			
3					-	-	-	-	-	-	-	-	-	-	-	-			
4					727	731	742	744	1,018	111,012	-	-	-	+ 276	+110,268	-	Escape ambiguity		
5	SDT				716	680	731	693	1,056	78,626	-	-	-	+ 325	+ 77,933	-	Escape ambiguity		
6					790	740	805	753	1,003	939	-	-	-	+ 198	+ 186	-			
7	South				505	520	520	533	624	623	-	-	-	+ 104	+ 90	-			
8	Leg				643	612	658	625	798	780	-	-	-	+ 140	+ 155	-			
9	25,000				708	692	723	705	870	754	-	-	-	+ 147	+ 49	-			
10					713	738	728	751	695	864	-	-	-	+ 33	+ 113	-			
11					734	707	740	720	816	787	-	-	-	+ 67	+ 67	-			
12					806	831	821	844	14,091	14,175	903	864	-	+ 13,270	+ 13,331	+ 82	Real time ambiguity		
13					668	625	683	638	1,815	791	1826	802	-	+ 1,132	+ 153	+1143	+ 20		
14					Blank film frame for data correlation												-	+ 164	
15					558	542	573	555	195,313	195,496	-	-	-	+194,740	+194,941	-	Random printout		
16					782	721	797	734	939	968	961	992	-	+ 142	+ 234	+ 164	+ 258		
17					568	570	583	583	860	745	849	717	-	+ 277	+ 162	+ 266	+ 134		
18					529	513	544	526	655	629	637	604	-	+ 111	+ 103	+ 93	+ 78		
19	SDT				679	668	694	681	-	-	-	-	-	-	-	-			
20	North				738	707	753	720	859	922	838	858	-	+ 106	+ 202	+ 85	+ 138		
21	Leg				658	636	673	649	849	793	803	736	-	+ 176	+ 144	+ 30	+ 87		
22	25,000				647	623	662	636	753	820	-	-	-	+ 91	+ 184	-	-		
23					595	607	610	620	634	582	-	-	-	+ 24	+ 38	-	-		
24					836	791	851	804	948	1,019	-	-	-	+ 97	+ 215	-	-		
25					-	-	-	-	-	-	-	-	-	-	-	-	-		
26					Blank film frame for data correlation												-	-	-
22 Sep 61 - Mission 24 - Sortie 1 - Target T-33/766 - Interceptor T-33/216 - Rocket E-57/244																			
1		+33	+33	-18	522	504	537	519	694	1,060	690	1069	-	+ 157	+ 541	+ 53	+ 556	1st sortie	
2					578	545	593	540	595	659	650	683	-	+ 2	+ 99	+ 57	+ 123		
3					479	461	494	476	532	559	535	565	-	+ 38	+ 83	+ 41	+ 89		
4					873	830	888	845	918	926	910	942	-	+ 30	+ 81	+ 22	+ 97		
5					559	542	574	557	574	547	536	522	-	-	-	-	-		
6	W470				891	846	906	861	895	871	932	878	-	+ 11	+ 10	+ 26	+ 17		
7	20 NM				628	653	643	648	639	609	641	606	-	+ 4	+ 59	-	-		
8	Leg				714	662	729	677	705	667	681	679	-	-	-	-	-		
9	25,000				710	679	725	694	717	726	721	746	-	-	-	-	-		
10					606	585	621	600	820	665	811	671	-	+ 199	+ 65	+ 190	+ 71		
11					761	732	776	747	796	725	780	725	-	+ 20	+ 22	+ 4	+ 22		
12					<77	547	592	562	533	694	539	713	-	-	-	-	-		
13					854	811	869	826	956	1,856	915	1844	-	+ 87	+ 1,030	+ 46	+1018		
14					Blank film frame for data correlation												-	-	-

[illegible]

\* Used as standard for comparison.

Data Point No.	Area & Altitude	Camera Data Corrections (ft)			Camera Data (ft)				MATS Data (ft)				Errors (ft)				Remarks
		Tar- get	Inter- cept	Rock- et	Uncorrected		Corrected		Real-Time Printout		Smoothed		Real-Time Printout		Smoothed		
					Miss	Escape	Miss	Escape	Miss	Escape	Miss	Escape	Miss	Escape	Miss	Escape	

22 Sep 61 - Mission 24 - Sortie 2 (continued)																	
28		+33		-18	726	713	741	728	1,046	1,624	-	-	+	303	+	896	-
29					818	796	833	811	1,040	1,313	-	-	+	207	+	502	-
30					958	915	973	930	1,531	1,872	-	-	+	558	+	942	-
31					619	609	634	624	770	972	-	-	+	136	+	348	-
32					757	741	772	756	853	791	-	-	+	81	+	35	-
33					831	811	846	826	927	1,160	-	-	+	81	+	334	-
34	SDT				1034	999	1049	1014	1,116	1,089	-	-	+	67	+	75	-
35	South				1019	982	1034	997	1,003	922	-	-	+	31	+	35	-
36	Leg				758	703	773	718	980	896	-	-	+	207	+	178	-
37	35,000				792	769	807	784	1,194	808	-	-	+	387	+	24	-
38					910	860	925	875	941	1,237	-	-	+	16	+	362	-
39					1139	1102	1154	1117	1,195	1,057	-	-	+	41	+	60	-
40					758	746	773	761	1,260	760	-	-	+	487	+	1	-
41					Blank film frame for data correlation												
42	SDT				984	951	999	966	1,259	1,205	-	-	+	260	+	239	-
43	North				743	723	758	738	819	870	-	-	+	61	+	132	-
44	35,000				632	594	647	609	633	703	-	-	+	14	+	94	-

23 Sep 61 - Mission BB 451 - Target T-33/766 - Interceptor T-33/342 - Rocket B-57/244																	
1		+33		-18	688	652	703	665	91,576	91,830	1683	2720	+	92,873	+	91,165	+
2					590	589	605	618	907	791	877	752	+	302	+	173	+
3					730	713	745	726	788	954	785	961	+	43	+	228	+
4					987	922	1002	935	1,157	1,260	1190	1277	+	55	+	325	+
5	SDT				731	695	746	708	1,218	1,064	1224	1099	+	472	+	356	+
6	South				539	523	554	536	1,177	1,034	1151	1012	+	623	+	498	+
7	Leg				671	640	686	653	848	935	812	943	+	162	+	282	+
8	25,000				1111	798	1126	811	1,369	887	1387	883	+	243	+	76	+
9					648	633	663	646	757	835	770	862	+	94	+	189	+
10					-	-	-	-	-	-	-	-	-	-	-	-	-
11					-	-	-	-	-	-	-	-	-	-	-	-	-
12					994	967	1009	980	1,280	922	1286	940	+	271	+	58	+
13					830	789	845	802	791	831	767	824	-	54	+	29	+
14					Blank film frame for data correlation												
15					757	739	772	752	927	1,002	926	1056	+	155	+	250	+
16					796	757	811	770	1,150	958	1178	977	+	339	+	188	+
17					425	408	440	421	582	545	591	499	+	142	+	124	+
18					603	465	618	478	728	730	764	764	+	110	+	252	+
19	SDT				565	467	580	480	663	646	639	682	+	83	+	166	+
20	North				698	575	713	588	888	883	861	839	+	175	+	295	+
21	Leg				462	436	477	449	499	567	485	538	+	22	+	118	+
22	25,000				457	436	472	449	536	552	474	522	+	64	+	103	+
23					756	712	771	725	912	975	900	1016	+	141	+	270	+
24					577	588	592	601	694	670	-	-	+	102	+	69	-
25					879	835	894	848	988	230,117	-	-	+	94	+	229,267	-
26					Blank film frame for data correlation												

1					688	652	703	665	91,576	91,830	1683	2720	+	92,873	+	91,165	+
2					590	589	605	618	907	791	877	752	+	302	+	173	+
3					730	713	745	726	788	954	785	961	+	43	+	228	+
4					987	922	1002	935	1,157	1,260	1190	1277	+	55	+	325	+
5	SDT				731	695	746	708	1,218	1,064	1224	1099	+	472	+	356	+
6	South				539	523	554	536	1,177	1,034	1151	1012	+	623	+	498	+
7	Leg				671	640	686	653	848	935	812	943	+	162	+	282	+
8	25,000				1111	798	1126	811	1,369	887	1387	883	+	243	+	76	+
9					648	633	663	646	757	835	770	862	+	94	+	189	+
10					-	-	-	-	-	-	-	-	-	-	-	-	-
11					-	-	-	-	-	-	-	-	-	-	-	-	-
12					994	967	1009	980	1,280	922	1286	940	+	271	+	58	+
13					830	789	845	802	791	831	767	824	-	54	+	29	+
14					Blank film frame for data correlation												
15					757	739	772	752	927	1,002	926	1056	+	155	+	250	+
16					796	757	811	770	1,150	958	1178	977	+	339	+	188	+
17					425	408	440	421	582	545	591	499	+	142	+	124	+
18					603	465	618	478	728	730	764	764	+	110	+	252	+
19	SDT				565	467	580	480	663	646	639	682	+	83	+	166	+
20	North				698	575	713	588	888	883	861	839	+	175	+	295	+
21	Leg				462	436	477	449	499	567	485	538	+	22	+	118	+
22	25,000				457	436	472	449	536	552	474	522	+	64	+	103	+
23					756	712	771	725	912	975	900	1016	+	141	+	270	+
24					577	588	592	601	694	670	-	-	+	102	+	69	-
25					879	835	894	848	988	230,117	-	-	+	94	+	229,267	-
26					Blank film frame for data correlation												

1					688	652	703	665	91,576	91,830	1683	2720	+	92,873	+	91,165	+
2					590	589	605	618	907	791	877	752	+	302	+	173	+
3					730	713	745	726	788	954	785	961	+	43	+	228	+
4					987	922	1002	935	1,157	1,260	1190	1277	+	55	+	325	+
5	SDT				731	695	746	708	1,218	1,064	1224	1099	+	472	+	356	+
6	South				539	523	554	536	1,177	1,034	1151	1012	+	623	+	498	+
7	Leg				671	640	686	653	848	935	812	943	+	162	+	282	+
8	25,000				1111	798	1126	811	1,369	887	1387	883	+	243	+	76	+
9					648	633	663	646	757	835	770	862	+	94	+	189	+
10					-	-	-	-	-	-	-	-	-	-	-	-	-
11					-	-	-	-	-	-	-	-	-	-	-	-	-
12					994	967	1009	980	1,280	922	1286	940	+	271	+	58	+
13					830	789	845	802	791	831	767	824	-	54	+	29	+
14					Blank film frame for data correlation												
15					757	739	772	752	927	1,002	926	1056	+	155	+	250	+
16					796	757	811	770	1,150	958	1178	977	+	339	+	188	+
17					425	408	440	421	582	545	591	499	+	142	+	124	+
18					603	465	618	478	728	730	764	764	+	110	+	252	+
19	SDT				565	467	580	480	663	646	639	682	+	83	+	166	+
20	North				698	575	713	588	888	883	861	839	+	175	+	295	+
21	Leg				462	436	477	449	499	567	485	538	+	22	+	118	+
22	25,000				457	436	472	449	536	552	474	522	+	64	+	103	+
23					756	712	771	725	912	975	900	1016	+	141	+	270	+
24					577	588	592	601	694	670	-	-	+	102	+	69	-
25					879	835	894	848	988	230,117	-	-	+	94	+	229,267	-
26					Blank film frame for data correlation												

1					688	652	703	665	91,576	91,830	1683	2720	+	92,873	+	91,165	+
2					590	589	605	618	907	791	877	752	+	302	+	173	+
3					730	713	745	726	788	954	785	961	+	43	+	228	+
4					987	922	1002	935	1,157	1,260	1190	1277	+	55	+	325	+
5	SDT				731	695	746	708	1,218	1,064	1224	1099	+	472	+	356	+
6	South				539	523	554	536	1,177	1,034	1151	1012	+	623	+	498	+
7	Leg				671	640	686	653	848	935	812	943	+	162	+	282	+
8	25,000				1111	798	1126	811	1,369	887	1387	883	+	243	+	76	+
9																	

25 Sep 61 - Mission 53 - Sortie 2 - Target T-33/760 - Interceptor T-33/342 - Rocket B-57/244																
Blank film frame for data correlation																
27		670	635	635	648	814	1,266	808	1,293	+	129	+	618	123	+	645
28		821	765	836	778	1,291	1,458	1,260	1,452	+	455	+	680	424	+	674
29		1178	1082	1193	1095	1,468	1,502	1,466	1,464	+	275	+	407	276	+	369
30		633	604	648	617	688	874	662	837	+	40	+	257	14	+	170
31		622	598	617	611	763	762	793	807	+	126	+	151	156	+	196
32	SDT	943	886	858	800	1,157	1,235	1,110	1,193	+	199	+	336	161	+	194
33	South	835	800	850	813	1,033	974	1,008	949	+	183	+	161	158	+	136
34	Leg	627	586	642	600	910	806	910	817	+	268	+	209	277	+	218
35	35,000	734	635	749	648	739	764	909	767	+	190	+	116	160	+	121
36		1043	957	1048	970	1,226	1,075	1,270	1,102	+	168	+	105	212	+	132
37		1270	1159	1285	1172	1,351	1,119	1,339	1,096	+	66	+	33	53	+	76
38		963	914	978	927	1,124	968	1,116	860	+	148	+	59	138	+	67
Blank film frame for data correlation																
40		420	403	435	416	523	547			+	88	+	131			
41		725	732	740	745	800	886	813	929	+	69	+	141	73	+	184
42		660	665	675	678	848	839	786	807	+	173	+	161	121	+	29
43		690	696	705	709	771	843	794	862	+	66	+	134	89	+	153
44		464	472	479	485	534	581	540	561	+	56	+	94	61	+	76
45	SDT	697	674	712	687	737	805			+	25	+	118			
46		990	921	1005	934	1,024	1,062	1,051	1,045	+	20	+	128	46	+	111
47	North	1045	971	1060	984	1,170	1,193	1,148	1,174	+	110	+	209	88	+	194
48	Leg	702	682	717	695	798	887	786	781	+	81	+	93	69	+	86
49	35,000	696	673	711	686	751	747	757	730	+	40	+	61	46	+	44
50		733	747	758	760	817	747	801	720	+	69	+	25	53	+	40
51		458	444	473	457	554	492	551	488	+	81	+	35	78	+	38
52																
53																
Film unassessable																
Film unassessable																

Miss ambiguity																	
32		535	518	550	531	55,688	531	55,640	614	+	55,138	+	52	+	55,000	+	83
33		556	543	571	556	650	739	665	736	+	88	+	183	+	94	180	
34		844	810	859	823	949	951	932	955	+	90	+	128	+	73	132	
35		938	887	953	900	1,124	1,385	1,133	1,421	+	171	+	485	+	180	521	
36		658	613	673	626	791	834	774	816	+	118	+	208	+	101	190	
37	SDT	564	544	579	557	691	711	739	773	+	112	+	154	+	160	216	
38	North	1055	1012	1070	1025	1,254	1,217	1,255	1,207	+	185	+	192	+	185	182	
39	Leg	1015	932	1039	945	1,207	1,301	1,178	1,410	+	177	+	436	+	148	465	
40	25,000	571	552	586	565	786	711	826	736	+	200	+	146	+	240	171	
41		734	747	804	760	938	906	906	900	+	129	+	146	+	97	140	
42		909	885	924	898	1,029	1,066	1,020	1,056	+	104	+	168	+	96	158	
43		1034	968	1040	981	1,199	1,161	1,194	1,121	+	150	+	180	+	145	140	
44		926	906	941	919	915	920	899	915	+	26	+	1	+	42	4	
45		860	807	875	820	1,286	1,101	1,259	1,050	+	411	+	281	+	384	230	
Blank film frame for data correlation																	
47		926	417	941	430	1,168	2,257	1,144	2,297	+	227	+	1,927	+	204	1867	
48		637	623	652	636	660	1,671	675	1,673	+	8	+	1,035	+	23	1037	
49		783	740	798	753	1,352	1,924	1,323	1,938	+	554	+	1,171	+	525	1185	
50		623	610	638	623	869	768	865	766	+	231	+	145	+	227	143	
51	SDT	715	695	730	708	755	1,188	738	1,180	+	25	+	480	+	8	481	
52	South	738	753	753	766	2,060	1,710	2,030	1,719	+	307	+	944	+	1,279	953	
53	Leg	761	741	776	754	1,076	1,456	1,153	1,489	+	300	+	702	+	377	735	
54	25,000	947	854	962	867	1,151	960	1,152	966	+	189	+	93	+	100	99	
55		1125	1062	1140	1075	1,370	1,193	1,346	1,204	+	230	+	118	+	206	129	
56		1126	1081	1141	1094	1,184	1,295	1,187	1,278	+	43	+	201	+	46	184	
57		1017	928	1032	941	1,094	1,461			+	62	+	520	+			
58		1055	1243	1070	1256	1,492	1,492	1,258	1,446	+	169	+	236	+	188	190	
Reading error																	

Data Point No.	Area & Altitude	Camera Data				Camera Data (ft)				Errors (ft)				Remarks	
		Corrections (ft)		Real-Time		Smoothed		Real-Time		Smoothed					
		Inter-Frame	Frame-to-Frame	Inter-Frame	Frame-to-Frame	Inter-Frame	Frame-to-Frame	Inter-Frame	Frame-to-Frame	Inter-Frame	Frame-to-Frame				
2 <sup>nd</sup> Sep 01 - Mission 1 - Target T-41/142 - Intercept 3-13/142 - Recast B-47/244															
1	447 <sup>00</sup> 4 <sup>th</sup> NM 35,000	-33	-31	-10	1250	1270	1223	1260	720	730	720	730	400	400	Ambiguity
2					1260	1270	1223	1260	720	730	720	730	400	400	
3					1300	1310	1263	1300	720	730	720	730	400	400	
4					1300	1310	1263	1300	720	730	720	730	400	400	
5					1300	1310	1263	1300	720	730	720	730	400	400	
6	447 <sup>00</sup> 4 <sup>th</sup> NM 35,000	-33	-31	-10	1250	1270	1223	1260	720	730	720	730	400	400	Film measured to left aircraft (interceptor) exhaust; right aircraft (target) left wing tip.
7					1260	1270	1223	1260	720	730	720	730	400	400	
8					1300	1310	1263	1300	720	730	720	730	400	400	
9					1300	1310	1263	1300	720	730	720	730	400	400	
10					1300	1310	1263	1300	720	730	720	730	400	400	
11	447 <sup>00</sup> 4 <sup>th</sup> NM 35,000	-33	-31	-10	1250	1270	1223	1260	720	730	720	730	400	400	Power failure during storm caused no printout
12					1260	1270	1223	1260	720	730	720	730	400	400	
13					1300	1310	1263	1300	720	730	720	730	400	400	
14					1300	1310	1263	1300	720	730	720	730	400	400	
15					1300	1310	1263	1300	720	730	720	730	400	400	
16	447 <sup>00</sup> 4 <sup>th</sup> NM 35,000	-33	-31	-10	1250	1270	1223	1260	720	730	720	730	400	400	Film measured to left aircraft (interceptor) left wing up; right aircraft (target) left wing tip.
17					1260	1270	1223	1260	720	730	720	730	400	400	
18					1300	1310	1263	1300	720	730	720	730	400	400	
19					1300	1310	1263	1300	720	730	720	730	400	400	
20					1300	1310	1263	1300	720	730	720	730	400	400	
21	447 <sup>00</sup> 4 <sup>th</sup> NM 35,000	-33	-31	-10	1250	1270	1223	1260	720	730	720	730	400	400	Film measured to left aircraft (interceptor) exhaust; right aircraft (target) left wing tip.
22					1260	1270	1223	1260	720	730	720	730	400	400	
23					1300	1310	1263	1300	720	730	720	730	400	400	
24					1300	1310	1263	1300	720	730	720	730	400	400	
25					1300	1310	1263	1300	720	730	720	730	400	400	
26	447 <sup>00</sup> 4 <sup>th</sup> NM 35,000	-33	-31	-10	1250	1270	1223	1260	720	730	720	730	400	400	Film measured to left aircraft (interceptor) left wing up; right aircraft (target) left wing tip.
27					1260	1270	1223	1260	720	730	720	730	400	400	
28					1300	1310	1263	1300	720	730	720	730	400	400	
29					1300	1310	1263	1300	720	730	720	730	400	400	
30					1300	1310	1263	1300	720	730	720	730	400	400	
31	447 <sup>00</sup> 4 <sup>th</sup> NM 35,000	-33	-31	-10	1250	1270	1223	1260	720	730	720	730	400	400	Film measured to left aircraft (interceptor) left wing up; right aircraft (target) left wing tip.
32					1260	1270	1223	1260	720	730	720	730	400	400	
33					1300	1310	1263	1300	720	730	720	730	400	400	
34					1300	1310	1263	1300	720	730	720	730	400	400	
35					1300	1310	1263	1300	720	730	720	730	400	400	
36	447 <sup>00</sup> 4 <sup>th</sup> NM 35,000	-33	-31	-10	1250	1270	1223	1260	720	730	720	730	400	400	Film measured to left aircraft (interceptor) left wing up; right aircraft (target) left wing tip.
37					1260	1270	1223	1260	720	730	720	730	400	400	
38					1300	1310	1263	1300	720	730	720	730	400	400	
39					1300	1310	1263	1300	720	730	720	730	400	400	
40					1300	1310	1263	1300	720	730	720	730	400	400	

21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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Data Point No.	Area & Altitude	Camera Data Corrections (ft)			Camera Data (ft)						Real-Time Data (ft)						Errors (ft)			Remarks
		Tar-Inter- get	Rock- cept	et	Uncorrected		Corrected		Real-Time		Smoothed		Real-Time		Smoothed					
					Miss	Escape	Miss	Escape	Printout	Smoothed	Miss	Escape	Printout	Miss	Escape					
7 Oct 61 - Mission 451 - Sortie 2 (Continued)																				
31		+60	+37		1100	1068	1151	1110	1.212	1.139	1.164	61	29	Unassessable		85	+ 54			
32					476	492	518	514	549	676	540	685	31	142	+ 31 + 151					
33					386	388	481	430	481	480	492	477	53	50	+ 64 + 47					
34					484	477	526	519	526	565	493	589	0	46	- 33 + 70					
35					712	701	754	743	755	766	666	724	49	23	- 88 - 19					
36					946	822	988	864	968	985	938	955	20	121	- 50 + 91					
37					939	869	981	911	924	946	914	972	52	35	- 67 + 61					
38					726	754	768	796	770	792	810	807	2	4	+ 42 + 11					
39					881	778	923	820	770	792	810	807	105	159	+ 108 + 165					
40					659	616	701	658	703	708	684	700	2	50	- 16 + 42					
41		+24			369	430	412	436	443	454	454	425	31	478	+ 42 + 489					
42		+60			794	759	836	801	910	1.006	901	623	74	205	+ 65 + 172					
43					1065	956	1107	998	1.342	1.472	1.304	1.587	235	574	+ 287 + 589					
44					Blank film frame for data correlation															
45					901	863	943	905	1.461	1.335	1.448	1.341	628	430	+ 605 + 436					
46					430	439	472	481	492	651	471	625	20	170	- 1 + 164					
47		+24			435	368	441	410	420	566	447	595	21	156	+ 6 + 187					
48		+24			382	404	386	410	601	1.025	715	1.057	225	615	+ 329 + 647					
49	WTDI	+60			903	883	945	924	883	1.030	874	1.042	62	105	- 70 + 157					
50	South				958	903	1000	945	863	923	874	928	137	22	- 126 - 17					
51	Leg				743	716	782	758	700	892	730	906	75	134	- 72 + 148					
52					741	737	783	779	764	930	739	877	19	151	- 44 + 108					
53	17,500				853	815	895	877	889	878	840	817	6	1	- 36 - 60					
54					767	777	800	810	788	915	768	933	41	97	- 41 + 114					
55					824	777	866	819	899	673	-	-	33	154						
56					Blank film frame for data correlation															
8 Oct 61 - Mission 401 - Sortie 1 - Target B-57/400 - Interceptor B-57/235 - Rocket B-57/244																				
4		+60	+37		600	540	642	586	644	631	620	624	2	43	- 13 + 36			One acct unassessable		
5					794	705	836	747	819	813	532	553	17	66	- 23 + 76					
6	WTDI				738	640	785	682	760	756	757	748	20	68	- 14 - 42			Film measured to left aircraft (interceptor) right engine; right aircraft (target) tail		
7	South				428	422	470	441	456	483	-	-	14	19	- 12 + 2					
8	Leg	+37			638	500	580	510	553	500	568	521	27	70	+ 22 + 49					
9	45,000	+37			753	651	795	693	786	763	817	742	9	85	- 92 + 95					
10		+60			Blank film frame for data correlation															
11					758	614	777	633	671	718	685	731	106	33	- 52 + 12			Film measured to left aircraft (interceptor) right engine, right aircraft (target) tail		
12		+37			498	454	540	496	512	529	488	508	28	48	- 34 + 32					
13		+60			579	512	621	554	496	602	587	586	25	30	+ 14 + 46					
14	WTDI				375	380	417	399	419	429	431	445	2	30	- 88 - 19					
15	North	+37			643	595	685	637	703	727	680	709	18	5	+ 72					
16	Leg	+60			694	606	736	648	701	724	675	703	35	76	- 51 + 55					
17	45,000	+37			351	357	370	363	349	372	395	360	21	9	+ 25 - 3					
18		+24			483	462	525	481	495	525	466	514	30	44	- 39 + 33					
19		+60			720	650	764	692	743	724	741	740	21	32	- 25 + 48					
20					705	606	747	658	717	685	734	714	30	27	- 13 + 56					
21					Blank film frame for data correlation															
22					Blank film frame for data correlation															

[illegible]

Data Point No.		Camera Data			Corrected Data (ft)				MA: IS Data (ft)				Errors (ft)				Remarks	
		Area & Altitude	Yar. Inter-cept	Rock- et	Uncorrected Miss	Escape	Miss	Escape	Real-Time Printout	Smoothed Miss	Escape	Miss	Printout	Smoothed Miss	Escape			
38			-0.1		405	458	437	401	401	474	447			38	46			Film measured to left aircraft (interceptor) right engine; right aircraft (target) null.
39					464	434	526	476	476	412	516			6	40			
40					472	408	540	451	451	443	400			34	60			
41			+37		462	435	484	440	440	441	460			150	117			
42			-0.2															Unassessable
43																		
44																		
45																		
46																		No reset, no printout
47																		
48																		
49																		
50																		Film measured to left aircraft (interceptor) right engine; right aircraft (target) left engine.
51																		
52																		
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21	011	010	050	038	1	20-	1,112	-	614	-	552	+	004	-	40	+ 21
22	045	029	004	007	-	047	010	-	601	-	17	-	-	-	40	+ 17
23	730	701	-40	720	-	077	040	-	-	-	69	-	61	-	58	+ 17
24	Blank film frame for data correlation															
25	788	743	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	755	750	001	776	-	007	018	-	700	-	6	+	40	-	32	- 3
27	435	420	404	440	-	403	444	-	444	-	1	+	11	-	0	+ 7
28	436	421	444	44	-	412	438	-	-	-	22	-	2	-	-	-
29	011	790	03	004	-	010	044	-	040	-	0	+	30	+	50	- 40
30	020	004	000	013	-	051	007	-	-	-	3	+	74	-	-	-
31	060	031	007	07	-	077	004	-	-	-	10	+	24	-	-	-
32	072	074	001	004	-	724	712	-	-	-	4	14	+	10	-	-
33	002	005	721	74	-	722	000	-	-	-	23	-	-	-	-	-
34	Blank film frame for data correlation															
35	406	415	414	435	-	427	47	-	033	-	49	-	31	-	0	+ 113
36	422	421	401	442	-	47	006	-	-	-	34	-	49	-	-	-
37	177	401	406	407	-	474	447	-	-	-	26	-	40	-	-	-
38	204	138	342	452	-	414	174	-	-	-	20	-	77	-	-	-
39	310	346	304	174	-	327	074	-	-	-	20	-	30	-	-	-
40	402	442	401	001	-	451	015	-	-17	-	50	-	10	+	10	- 40
41	443	747	042	740	-	707	115	-	-	-	34	-	03	-	-	-
42	033	704	052	043	-	011	011	-	-	-	41	-	42	-	-	-
43	527	545	540	504	-	50	741	-	-	-	4	14	17	-	-	-
44	425	426	444	447	-	410	447	-	-	-	21	-	7	-	-	-
45	404	471	404	000	-	40	015	-	-	-	4	-	20	-	-	-
46	Blank film frame for data correlation															
47	722	070	741	004	-	710	74	-	742	-	22	-	70	-	0	+ 00
48	417	034	430	051	-	44	000	-	412	-	14	-	40	-	4	- 40
6 Oct 61 - Mission 451 - North 2 - Target P-51/A 0 - Interceptor B-57 314 - Rocket P-57 244																
1	Blank film frame for data correlation															
2	030	031	741	715	-	742	006	-	701	-	1	-	15	-	40	+ 11
3	000	406	011	011	-	001	740	-	070	-	40	-	10	-	2	-
4	025	030	007	077	-	004	07	-	00	-	2	+	0	-	12	- 1
5	540	070	001	021	-	024	00	-	-	-	40	+	20	-	0	+ 10
6	522	040	004	002	-	074	015	-	073	-	11	+	33	-	0	+ 10
7	400	037	022	449	-	445	004	-	-	-	10	-	4	-	-	-
8	441	407	404	470	-	417	024	-	400	-	10	-	0	-	0	+ 10
9	409	402	442	444	-	445	404	-	404	-	3	+	0	-	0	+ 10
10	407	377	073	317	-	47	414	-	14	-	14	-	13	-	14	- 40
11	407	377	073	317	-	47	414	-	14	-	14	-	13	-	14	- 40
12	426	447	000	000	-	443	012	-	001	-	21	+	13	-	14	- 40
13	726	722	704	704	-	704	701	-	-	-	14	-	14	-	14	- 40
14	452	470	004	012	-	007	405	-	-	-	14	-	14	-	14	- 40
15	Blank film frame for data correlation															
16	404	404	410	430	-	474	005	-	400	-	10	-	41	-	4	+ 110
17	444	007	007	070	-	441	008	-	-	-	04	-	11	-	-	-
18	400	440	407	011	-	400	005	-	004	-	10	-	10	-	-	-
19	400	404	011	004	-	404	001	-	-	-	10	-	10	-	-	-
20	507	507	000	003	-	029	000	-	-	-	10	-	10	-	-	-
21	000	745	000	707	-	711	744	-	-	-	14	-	42	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	Blank film frame for data correlation															
24	560	000	074	074	-	067	004	-	-	-	2	-	110	-	-	-
25	430	022	457	026	-	000	022	-	-	-	41	-	0	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Data Point No.	Area & Altitude	Camera Data			Camera Data (ft)			MATIS Data (ft)			Errors (ft)			Remarks
		Tar-Inter- get	Rock- cept et	Corrections (ft)	Camera Data (ft)			Real-Time Printout	Smoothed		Real-Time Printout	Smoothed		
					Uncorrected	Corrected	Miss		Escape	Miss		Escape	Miss	
9 Oct 61 - Mission 452 - Sortie 2 (Continued)														
31														
32														
33														
34														
35														
36														
37														
38	WTDI North	+37	+37	-18										
39	South Leg	+37	+24											
40	35,000	+24	+24											
41														
42														
43														
44														
45	South Leg	+37	+24											
46														
Blank film frame for data correlation														
11 Oct 61 - Mission 453 - Sortie 2 - Target B-57/509 - Interceptor B-57/235 - Rocket B-57/244														
4														
5														
6														
7														
8	WTDI South	+24	+24											
9	Leg													
10	35,000													
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														
21	WTDI South	+24	+24											
22	Leg													
23	17,500													
24														
25														
26														
27														
28														
29	WTDI North	+24	+24											
30	Leg													
31														
32														
33														
34														

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- I. Tracking
2. Rocket trajectories - scoring
3. MATTS
- I. AFSC Project 7840
- II. Kantak, John F., Lt, USAF
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